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June 25, 2018

Kelly Zylstra, P.E.
Operations Manager
Waukesha Water Utility
115 Delafield Street
Waukesha, WI 53187

Subject: Great Lakes Water Supply Program
Task 5-110 D1 Model Update Calibration Technical Memorandum
GWA PM DEL 049

Dear Ms. Zylstra:

In accordance with Task 5-110 Model Update and Calibration of our Agreement, we are hereby delivering via the Great Water Alliance SharePoint site a draft of Deliverable 5-110 D1 Model Update Calibration Technical Memorandum.

The purpose of this deliverable is to summarize the process and steps to update the InfoWater distribution system model. The model update consisted of reallocating the water demand using the most current billing and water use data available from WWU, and incorporating newly constructed and planned improvements into the hydraulic model. In order to calibrate the model, field hydrant flow testing and monitoring was performed to gain perspective on both a steady state and extended period simulation. Operational controls were adjusted so results from the model matched both SCADA data obtained from WWU and the field hydrant test data gathered during the calibration period.

The model will be used to identify system improvements and recommendations for system operation that support the integration of a new water supply. The model can also be used in future analysis to optimize system performance and capital improvement project planning.

Yours very truly,

Greeley and Hansen LLC

[redacted]

Catharine M. Richardson, P.E.
Deputy Program Manager

CMR/lam
Encl (1): Deliverable 5-110 D1 Model Update Calibration Technical Memorandum (electronic version)
cc: Deliverable 5-110 D1 file

Great Lakes Water Supply Program

GREAT WATER ALLIANCE

DRAFT

5-110 D1 Model Update and Calibration Technical Memorandum

June 2018

Waukesha Water Utility
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EXECUTIVE SUMMARY

The Waukesha Water Utility (WWU) developed a computerized hydraulic model of its water distribution system to use for system analysis and evaluation. This hydraulic model is updated periodically as new pipelines are constructed as capital improvements and the operational strategy within the distribution system changes. As part of the effort for the Great Water Alliance (Program), the existing hydraulic model was updated to reflect current conditions to identify system improvements and recommendations for system operation that support the integration of a new water supply. The model update consisted of reallocating the water demand using the most current billing and water use data available from WWU, and incorporating newly constructed and planned improvements into the hydraulic model. In order to calibrate the model, field hydrant flow testing and monitoring was performed to gain perspective on both a steady state and extended period simulation. Operational controls were adjusted so results from the model matched both SCADA data obtained from WWU and the field hydrant test data gathered during the calibration period. The results of the calibration showed that 91% of monitored locations were within 5 psi of field pressure and 78% were within 3 psi of the field measured pressure, demonstrating a well-calibrated model. The updated and calibrated model can be used in future analysis for optimizing system performance and capital improvement project planning.

SECTION 1 Introduction

The WWU developed a computerized hydraulic model of its water distribution system which is updated periodically with capital improvement and operational information. The purpose of this technical memorandum is to document the integration of system updates and calibration of the hydraulic model to in-the-field hydrant flow and pressure testing data. The hydrant flow testing was done to represent a static snapshot in time as well as a longer extended period simulation (EPS) of the system to calibrate the model to.

SECTION 2 Data Collection and Overview

This section provides an overview of WWU's water distribution system infrastructure and operation.

2.1 Data Collection

To update the hydraulic model and understand the operation of the WWU distribution system, the following data was collected and reviewed:

- Distribution System Geographic Information System (GIS) database, including GIS files for water mains (include attribute data such as diameter, material and year of installation), pumps, tanks, PRVs and water accounts
- Background GIS, including streets, ground contours, and aerial photos
- SCADA records
- Water billing records in electronic format, including address and monthly usage
- Storage reservoir and/or tank information
- Valve information, including normally closed valves
- Pump station information, including pump curves, and pump controls
- Record drawings for the WTP, storage tanks, and newly constructed water mains
- Water production records
- Existing water distribution model

2.2 Overview

The water distribution system consists of one groundwater well pumping directly into the distribution system, five groundwater well facilities consisting of well, ground level reservoir, and booster pump station, two groundwater well facilities consisting of groundwater well and water treatment plant, one groundwater well facility consisting of three groundwater wells, water treatment plant, ground reservoir, and booster pumping station, five elevated water storage tanks, one ground level elevated water storage tank, nine booster pump stations supplying nine separate pressure zones, two PRVs supplying two separate pressure zones, and approximately 330 miles of transmission and distribution water mains. The general location and layout of water system facilities in the distribution system are illustrated in Figure 2-1.

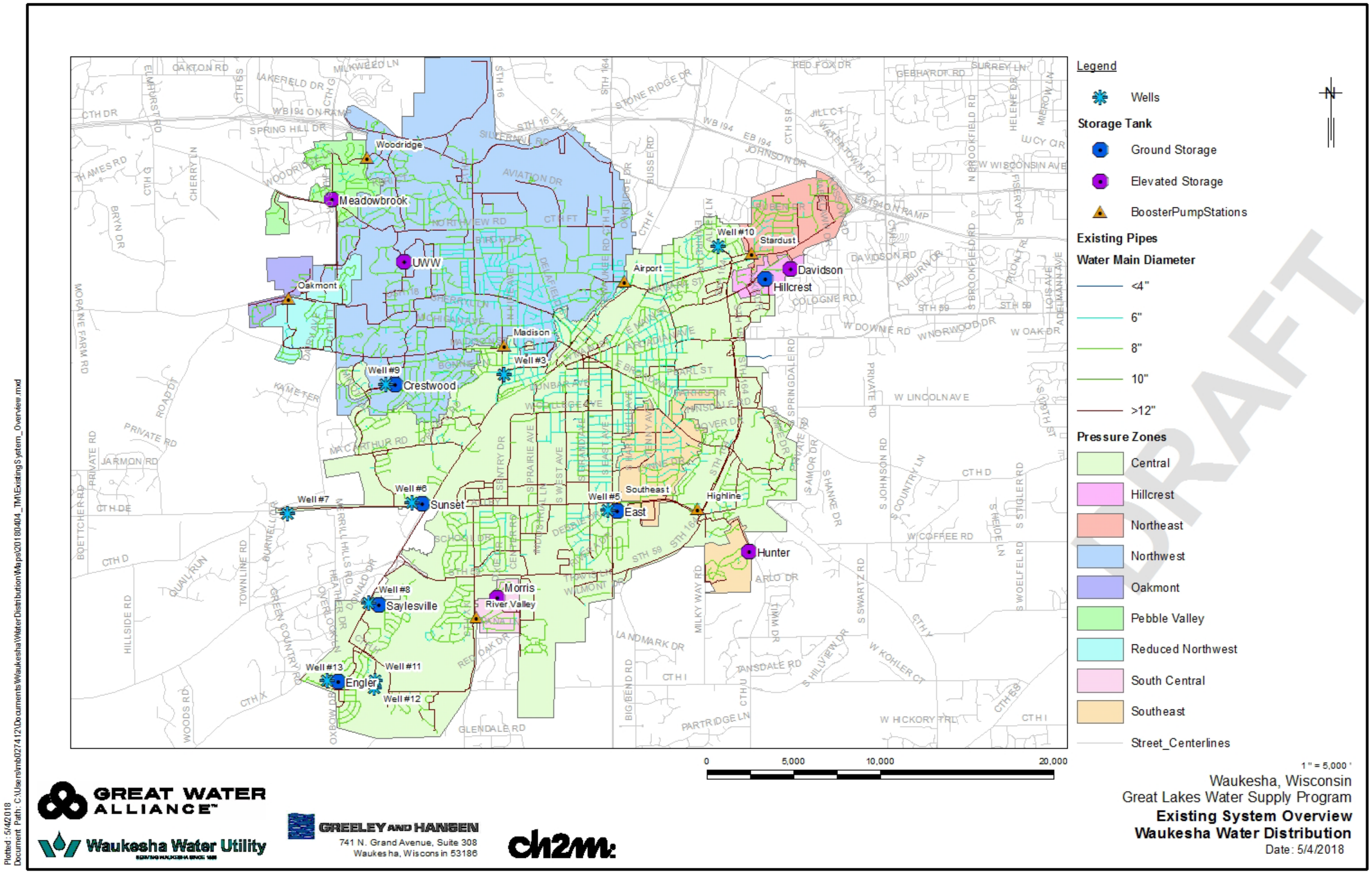


Figure 2-1 Existing Distribution System Overview

SECTION 3 Model Update

The update of the WWU hydraulic model included a review of the GIS to update the hydraulic model with improvements that have been constructed since the last model update that occurred in 2013, and update and reallocation of water demand, and development of updated diurnal curves. These improvements were incorporated by using the WWU GIS data that was supplemented with tabular summaries of distribution that was provided by WWU.

3.1 GIS

The WWU GIS data was utilized to update the InfoWater distribution system model to maintain the 1:1 relationship between the GIS and the hydraulic model. InfoWater is a GIS based application and runs through the ArcMap interface. There is an automated method through InfoWater of incorporating GIS data into an existing model, which was used to update (add) the new pipes and remove the newly decommissioned pipes in the distribution system. Due to the method WWU employs to update their GIS information, several areas within the model were disconnected and had to be manually reconnected in the InfoWater model, and pipe IDs had to be updated to try and maintain the 1:1 relationship between the GIS and the hydraulic model. Understanding the requirements of InfoWater to maintain the hydraulic model appropriately, WWU has changed their method of GIS upkeep to make model updates easier in future.

3.2 Demand Development and Allocation

Based upon changes in water usage, and new areas of development in the system, the demand within the system needed to be updated and re-allocated to match existing conditions. The reallocation was done through utilizing billing data, and then updated diurnal curves were developed for each of the pressure zones within the system for application on the demand nodes.

3.2.1 Billing Data

Billing data for 2016 provided the basis for reallocation of the water demand. The billing data was analyzed, geocoded through the use of the account address, or tax key if no address was available. This point demand data was then spatially linked to model junctions for allocation of demand in 2016. The demand represented by the billing data was then scaled to the production data totals to reflect the total amount of water that is delivered to the distribution system.

3.2.2 Diurnal Demand Curves

Diurnal demand curves were developed by conducting a water balance around each pressure zone. The water balance calculates the instantaneous water demand in a pressure zone by summing the supply flow to a zone, subtracting the supply to other zones from the specified zone, and taking into account the flow in and out of water storage within the zone. SCADA information on supply flows and tank levels provided by WWU was critical to develop the water balance. The tank level data was used to calculate the instantaneous flow from the water storage facilities. A summary of diurnal demand patterns for each zone is shown in Appendix A.

3.3 Demand Conditions

In addition to updating the water model for the existing (2016) water demand, the Approved Diversion demand condition was also updated in the hydraulic model. This Approved Diversion demand condition represents the future demand projection identified in the Great Lakes-St. Lawrence River Basin Water Resources Council Final Decision. Discussions were held with WWU staff to identify the approach for allocating Approved Diversion demand to the system so that a system-wide growth factor was not applied. Table 3-1 summarizes the existing and Approved Diversion demand conditions updated in the hydraulic model. The additional demand between existing and the Approved Diversion demand was allocated to defined areas within each Pressure Zone according to recommendations from WWU, based on WWU's knowledge of where the system is completely built out and where additional infill demand is likely to occur. The Pressure Zones identified where the Approved Diversion demand is likely had that additional demand divided evenly among the model nodes within those identified development areas. Pressure Zones identified by WWU that the Approved Diversion demand was allocated to can be found in Table 3-2.

Table 3-1 Existing and Approved Diversion Demand Conditions

Time Period	Average Day Demand (mgd)	Maximum Day Demand (mgd)
Existing	6.6	10.8
Approved Diversion	8.2	13.6

Table 3-2 Pressure Zones Identified for Approved Diversion Demand Allocation

Pressure Zone	Approved Diversion Demand Allocated – ADD (mgd)	Approved Diversion Demand Allocated – MDD (mgd)
Central	0.32	0.56
Oakmont	0.32	0.56
Northwest	0.32	0.56
Pebble Valley	0.32	0.56
Reduced Northwest	0.32	0.56

3.4 Future Model Maintenance

Model maintenance is a key component of providing a reliable, sustainable tool for assessing distribution system response to events, evaluating and planning future improvements to meet growth or changes in customer demand, and evaluating impacts from changes in system operation. As described in the next sections, the WWU hydraulic model has been calibrated to existing conditions and the level of calibration was robust to support identifying required system improvements and defining future system operation with the change in water supply.

A hydraulic model is a living, dynamic tool and to continue to have confidence in the results the model provides, periodic updates of the hydraulic model to incorporate replaced or new pipeline segments should be performed. A typical timeframe to perform these physical updates to the hydraulic model is on an annual basis unless there is a need to evaluate or address a system performance issue in an area where pipelines have been constructed or replaced. The WWU hydraulic model was originally developed with a one to one (1:1) relationship between the WWU GIS pipe data and the hydraulic model. Since WWU uses this 1:1 relationship between the GIS and the model, how WWU breaks pipe segments in the GIS (and ultimately the model) as new pipes are constructed that intersect existing pipes is very important. Existing pipes that are split by new pipes need each section of the pipe to retain a new, unique identification so pipes do not disconnect once imported into the model from GIS. Defining the relationship between GIS and the hydraulic model provides a more seamless import of GIS data into the hydraulic model. A protocol for the ongoing maintenance of the hydraulic model is being developed, and this protocol will define the fields used to track feature IDs and additions to the GIS.

In addition to updating the physical model network, updates to the water demand allocation should also be periodically reviewed and updated. A review of water demand and production should be done annually to assess how differently the water usage is in each pressure zone as compared to the allocated demand in the hydraulic model and if a demand updated is needed. As noted in earlier sections, the water demand was allocated based upon recent billing records, using the spatial location of the water demand and provides a realistic distribution of water demand. The threshold of water demand changes (increases or decreases) that triggers reallocating water demand should be defined so that the model continues to be an accurate representation of water usage across the system.

Once upgrades are made to the hydraulic model for infrastructure or demand changes, the model's capability to accurately predict flows and pressures should be validated against SCADA information. This validation step is different than a full-scale calibration as it provides a general sense that the model is continuing to predict similar performance that is observed with SCADA. If there is a wide variance (greater than 10% – 15%) in the model's performance as compared to the SCADA data, a field testing program for full-scale calibration should be developed to identify where the discrepancy in the model's prediction and the monitored performance lies. The initial step for a model validation is recommended as the first assessment since a full-scale calibration takes time and effort to plan and is not always needed, depending upon the extent of the upgrades and demand changes. A full-scale model calibration should be performed on a three to five-year cycle to confirm that system-wide performance continues to be representative at additional locations throughout the WWU system.

SECTION 4 Model Calibration

Once the existing demand was updated and diurnal curves were developed, the model was calibrated to measured field data to confirm and validate the model's predictive capabilities. The calibration process was performed by conducting field testing that measured pressure response to measured flows from selected hydrants throughout all of the pressure zones. In addition to the static response from hydrant flow testing, dynamic pressure monitoring was performed to capture the system performance at selected hydrants for a weeklong interval of normal system operation.

4.1 Static Field Testing: Hydrant Flow Tests

Flow and pressure testing was done at 23 locations throughout all of the system pressure zones in order to capture system response under high flow conditions. See Figure 4-1 for an overview of all hydrant test locations, labeled by test number. A flowing hydrant and an adjacent residual hydrant were selected for each test, and up to four additional monitoring locations (residual hydrants) that were used for other hydrant flow tests monitored pressure in other parts of the system during each hydrant flow test. The "P" and "F" designations in Figure 4-2 stand for pressure (residual) hydrant and flow hydrant respectively. A pressure drop of 10 psi at the residual hydrant was targeted for these tests, and the majority of the tests had a sufficient pressure drop with only a few tests that did not achieve a 10 psi pressure drop. While a pressure drop of less than 10 psi is not ideal, this data point is still informative for calibration. The collected field test data was used to perform the steady state calibration of the model, which represents a snapshot of system operation. See Table 4-1 for the field testing data summary.

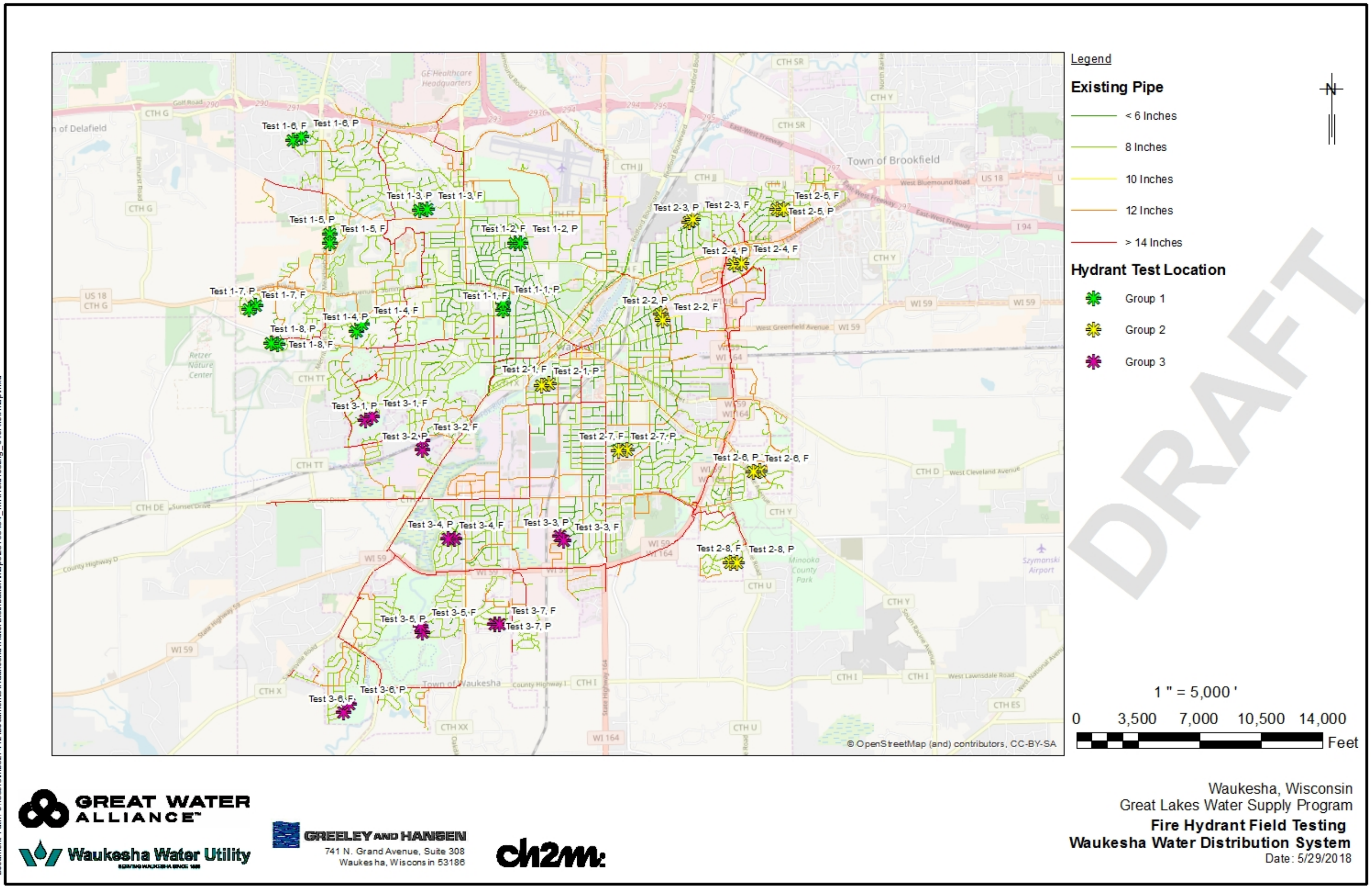


Figure 4-1 Field Testing Overview Map

Table 4-1 Field Testing Data Summary

Test ID	Pressure Zone	Flow (GPM)	Static Pressure (PSI)	Residual Pressure (PSI)	Pressure Drop (PSI)
1-1	Northwest	1,900	68	58	10
1-2	Northwest	1,700	72	60	12
1-3	Northwest	1,750	68	63	5
1-4	Northwest	2,050	90	82	8
1-5	Northwest	1,700	58	46	12
1-6	Pebble Valley	1,600	56	47	9
1-7	Oakmont	1,400	46	41	5
1-8	Reduced Northwest	1,750	79	59	19
2-1	Central	950	82	49	33
2-2	Central	1,300	56	33	23
2-3	Central	1,550	50	46	4
2-4	Hillcrest	1,050	84	68	16
2-5	Northeast	1,600	62	55	7
2-6	Central	1,500	49	45	4
2-7	Southeast	1,200	88	50	38
2-8	Southeast	1,950	73	63	10
3-1	Central	1,400	62	47	15
3-2	Central	1,850	72	62	9
3-3	Central	1,900	74	71	3
3-4	Central	2,000	84	79	5
3-5	Central	2,000	82	72	10
3-6	Central	2,100	86	77	9
3-7	South Central	1,600	57	40	17

After the hydrant flow tests were completed to support the steady state calibration, ten pressure monitors were placed on hydrants throughout the Central and Northwest pressure zones and left in place for one week to capture the system operation for a longer time period. The data from these monitors was used to complete the EPS calibration, which represents the system response and performance over time. The system performance varies based upon diurnal demand variation as well as changes in system operation such as pump stations turning on and off and tanks filling or draining. See Figure 4-2 for an overview of the ten extended period monitor locations. The pressure monitors in Figure 4-2 are labeled by Asset ID number.

Table 4-2 shows a summary of the pressure monitor data that was captured over the week-long monitoring period. Both the pressure and the hydraulic grade line (HGL) are shown in Table 4-2. The minimum, maximum, and average HGL was determined based on the minimum, maximum, and average pressures monitored over the period, and this evaluation of HGL was performed to confirm that the monitors were accurately capturing the pressure data for the pressure zones they were located in.

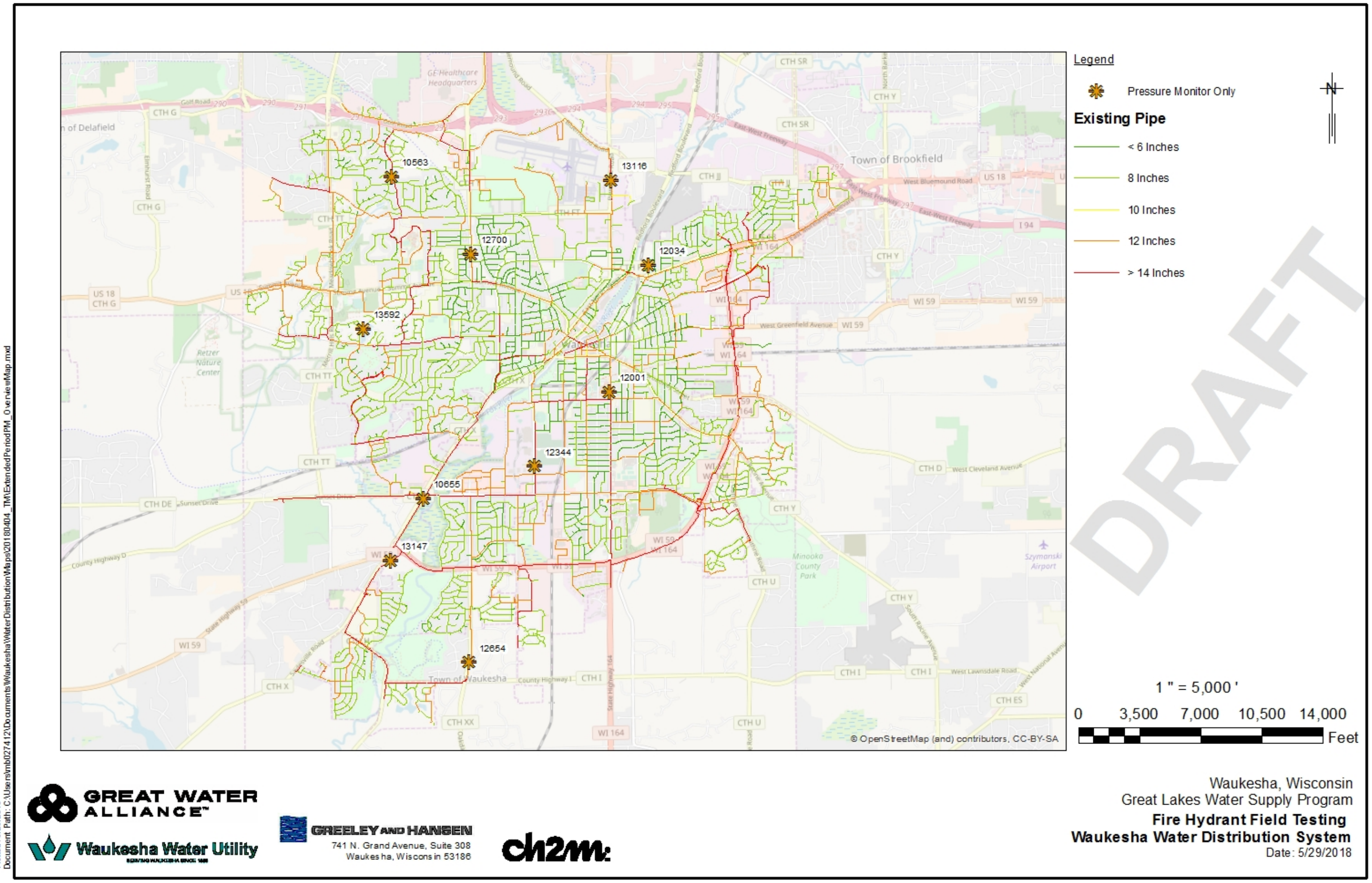


Figure 4-2 Extended Period Pressure Monitor Overview Map

Table 4-2 Extended Period Pressure Monitoring Data Summary

Test ID	Minimum Pressure (PSI)	Maximum Pressure (PSI)	Average Pressure (PSI)	Min Calculated HGL (ft)	Max Calculated HGL (ft)	Avg Calculated HGL (ft)	Pressure Zone
4-1	50	74	63	963	1018	993	Central
4-2	41	66	51	930	989	954	Central
4-3	47	63	56	972	1009	993	Central
4-4	61	72	68	979	1005	994	Central
4-5	55	92	75	1036	1122	1083	Northwest
4-6	78	93	85	1065	1101	1083	Northwest
4-7	77	100	89	1057	1112	1086	Northwest
4-8	67	82	75	1066	1102	1084	Northwest
4-9	60	83	72	967	1019	995	Central
4-10	73	88	80	973	1008	990	Central

4.2 Steady State Calibration

Using the data collected in Table 4-2, simulations for the steady state calibration were set up as individual model scenarios that simulated every individual hydrant flow test. The boundary conditions used for these scenarios were developed from field data and from the SCADA data obtained for the system. The calibration process consisted of comparing field measured data and model results for static pressures and residual pressures. To be considered a well calibrated model that can be used for planning and operational guidance, the goal of the steady state calibration is to get 90% of tests within 10% of field pressure.

Initial comparison of model results to field monitored data indicated that several tests required additional investigation to align the model predicted data to the field measured data at the particular location. The primary changes in the model simulation included reconnecting disconnected pipes and adjusting pump operation, the steady state calibration was all within 8% of monitored data, where 10% is desired. No pipe friction factors were adjusted during calibration. See Table 4-3 for a summary of the individual steady state calibration results.

The results of the calibration for the WWU system were that 96% were within 5 psi of field pressure and 74% were within 3 psi of the field measured pressure, demonstrating a well calibrated model. See Table 4-4 for an overall summary of the model calibration performance.

By having additional pressure monitors installed during each hydrant flow test, the approach for the WWU calibration also assessed the influence of nearby fire flow tests on all monitoring locations that were in place at the time of the test, providing additional confidence in the performance of the entire system and not just isolated areas. An example of this is hydrant 10241, which was the residual pressure hydrant for Test 2-6. This location monitored the pressure drop during the hydrant flow for Test 2-6, but also showed a dip in pressure for tests nearby as well. See Figure 4-3 for the pressure monitored throughout the Group 2 tests.

Table 4-3 Steady State Calibration Results Summary

Test ID	Field Static Pressure (PSI)	Field Residual Pressure (PSI)	Model Static Pressure (PSI)	Model Residual Pressure (PSI)	Static Pressure Difference (PSI)	% Pressure Difference	Field Pressure Drop (PSI)	Model Pressure Drop (PSI)	Diff. in Pressure Drop (PSI)
1-1	68	58	65	54	3	5%	10	10	0
1-2	72	60	68	60	3	5%	12	8	4
1-3	68	63	66	65	2	4%	5	0	5
1-4	90	82	88	84	2	2%	8	5	4
1-5	58	46	57	50	1	3%	12	7	6
1-6	56	47	60	49	-4	-7%	9	11	-2
1-7	46	41	44	40	1	3%	5	4	1
1-8	79	60	85	66	-6	-7%	19	19	0
2-1	82	49	78	47	4	5%	33	31	2
2-2	56	33	58	37	-1	-2%	23	20	3
2-3	50	46	50	46	0	0%	4	4	0
2-4	84	68	83	67	1	2%	16	16	0
2-5	62	55	60	55	2	3%	7	5	2
2-6	49	45	46	45	3	5%	4	2	2
2-7	88	50	89	50	-1	-1%	38	39	-1
2-8	73	63	75	69	-2	-2%	10	6	4
3-1	62	47	60	50	2	4%	15	10	5
3-2	72	62	70	67	1	2%	9	3	6
3-3	74	71	71	70	3	4%	3	2	2
3-4	84	79	82	81	2	2%	5	1	4
3-5	82	72	80	73	2	3%	10	7	3
3-6	86	77	83	80	3	4%	9	2	7
3-7	57	40	56	48	1	1%	17	9	8

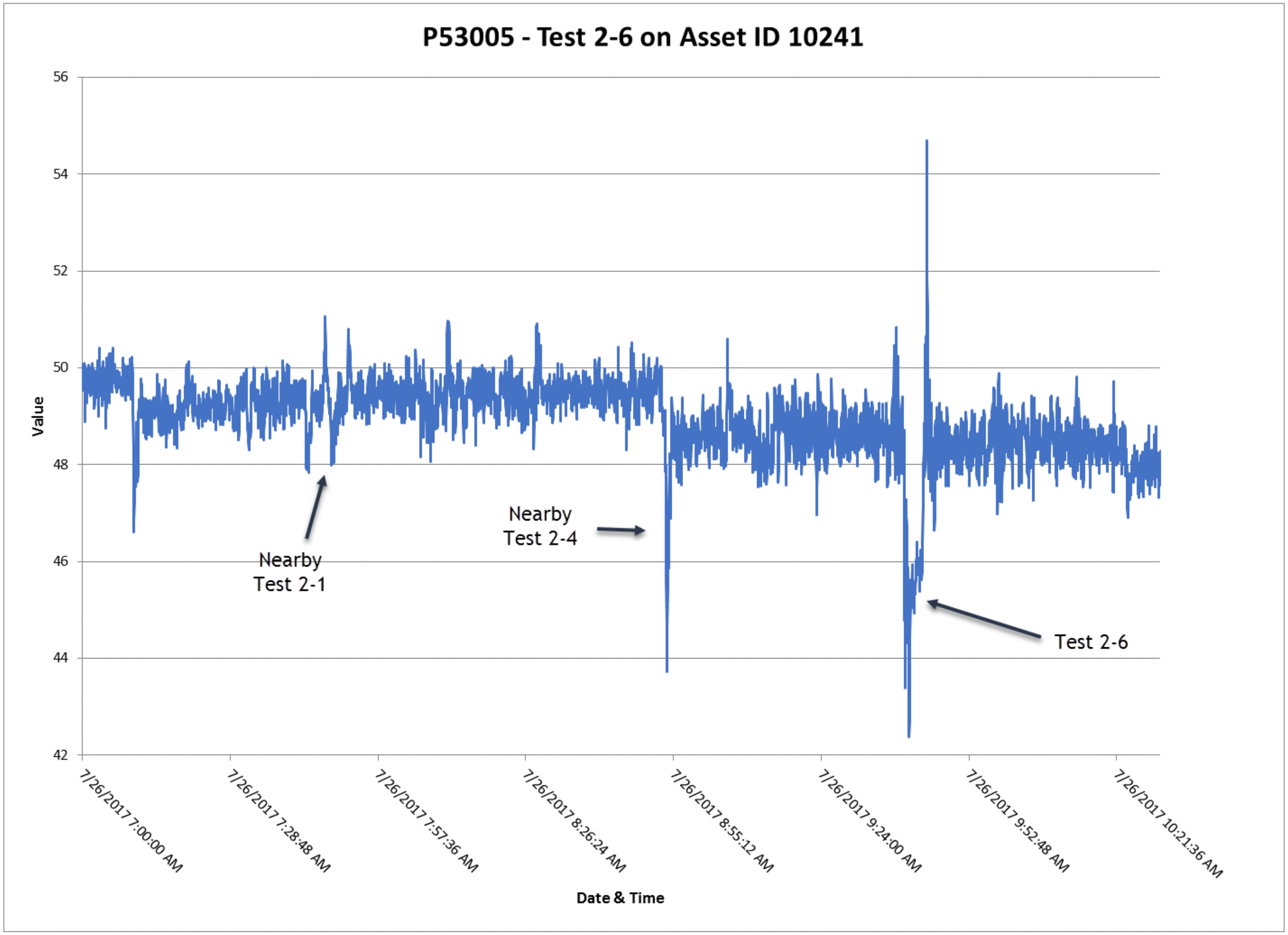


Figure 4-3 Pressure monitored by P53005 on Asset ID 10241 for Test Group 2

Table 4-4 Model Calibration Performance Summary

		Static				Residual	
	Total Number of Flow Tests	Within 10%	Within 5%	Within 5 psi	Within 3 psi	Within 8 psi	Within 5 psi
Number of Tests in each Category	23	23 (100%)	19 (83%)	22 (96%)	17 (74%)	22 (96%)	19 (83%)

4.3 EPS Calibration

Monitoring of normal system operation was completed with the installation of pressure monitors throughout the Northwest and Central zones. This monitoring effort was done to complete an EPS calibration. Monitors were in place for one week starting July 27, 2017 and ending on August 3, 2017. Figure 4-2 shows the location of the 10 monitors that were in place for that week. The information from these monitors was compared with the model predicted performance (pressure)at nodes that aligned with the monitored locations, see Table 4-5 for a summary of the hydrant ID, model ID, and physical location for the pressure monitoring points. and Figure 4-4 for an overview of the pressure recorded during the monitoring period.

Table 4-5 Extended Period Monitor Hydrant Locations and Matching Model Nodes

Pressure Monitor	Hydrant ID	Model Node ID	Location
PS4 S1	10655	J9784	St Paul & Sunset
PS4 3B	10563	J4162	University Dr & Keri Ct
P70909	12700	J27222	Grandview Blvd & Easy St
P59817	13116	J32134	Pewaukee Rd & Northview Rd
P70906	13592	J3456	Comanche La & Walden Cir
P31529	13147	J7960	Saylesville Rd/STH 59
P53005	12344	J12776	Prairie Ave & Progress Ave
P59819	12001	J20094	East Ave & Wright St
P59736	12034	J21410	Whiterock Ave & Gale St
P59735	12654	J8616	Oakdale Dr & Red Oak Dr

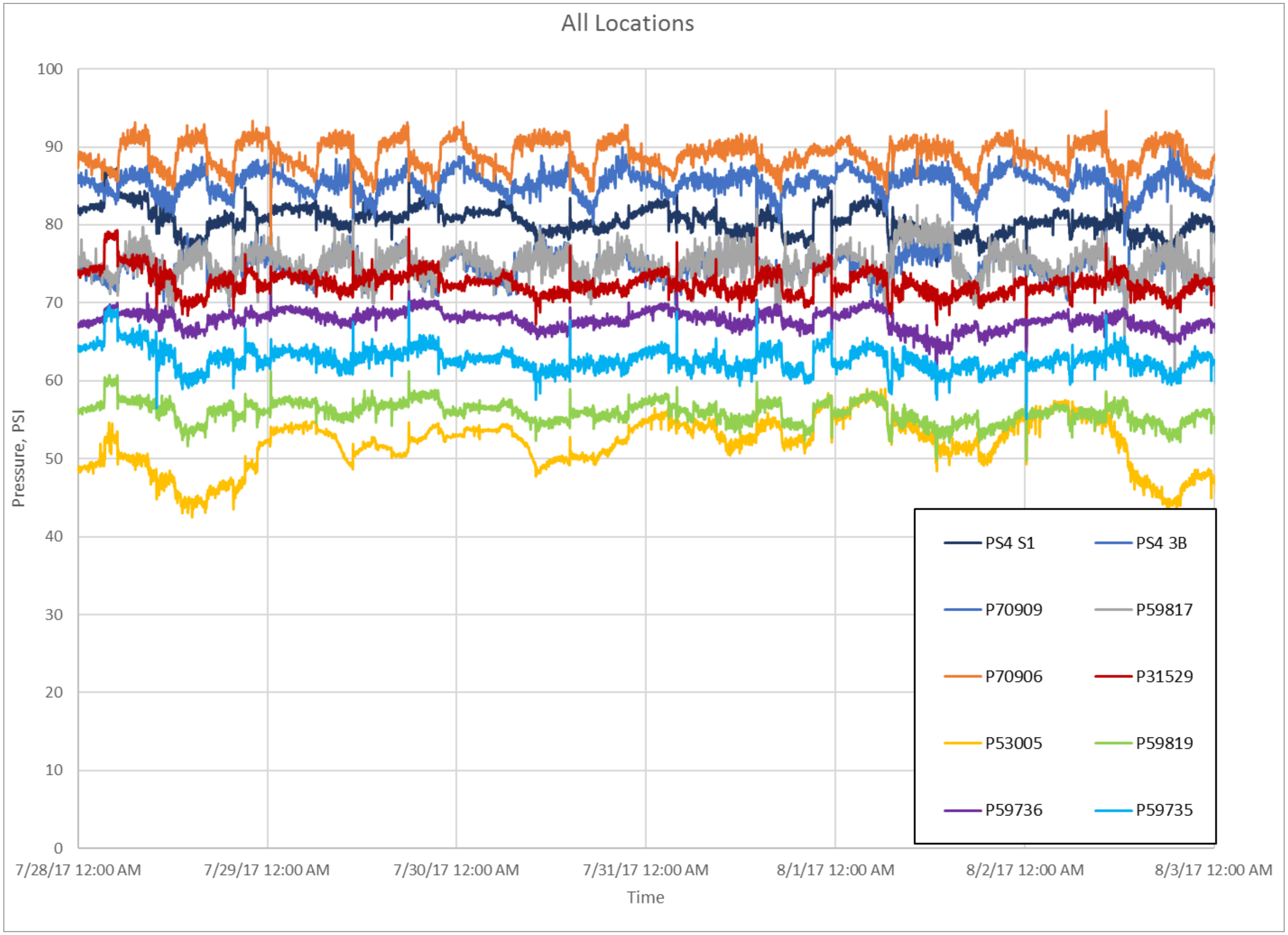


Figure 4-4 All Monitored Locations

At each of the listed nodes, the model predicted pressure and the field monitored pressure were compared. The graphical comparison of the pressures is shown in Figures 4-5 through 4-14, and Table 4-6 presents a comparison average, minimum, and maximum pressure between the model predicted data and the field monitored data of every monitored location. The difference in average pressure over the monitored time period between the model results and the monitored hydrants is 4 psi or less apart from the monitor at hydrant 12344 at North Prairie Avenue and Progress Avenue which shows an approximately 19 psi difference between the modeled average pressure and the monitored pressure. This variation is assumed to be an error in the pressure monitor since every other monitor recorded pressures much closer to predicted model results, and the hydraulic grade line evaluation of the pressure monitor data does not align with the location the monitor was installed.

Table 4-6 Extended Period Monitoring and Simulated Data Comparison

Pressure Monitors					Model Results			
Pressure Monitor	Hydrant ID	Min (psi)	Max (psi)	Average (psi)	Model Node ID	Min (psi)	Max (psi)	Average (psi)
PS4 S1	10655	73	88	80	J9784	73	92	84
PS4 3B	10563	78	93	85	J4162	83	88	86
P70909	12700	67	82	75	J27222	72	77	75
P59817	13116	55	92	75	J32134	70	75	73
P70906	13592	77	100	89	J3456	87	93	90
P31529	13147	60	83	72	J7960	63	82	74
P53005	12344	41	66	51	J12776	59	78	70
P59819	12001	47	63	56	J20094	48	64	58
P59736	12034	61	72	68	J21410	63	73	69
P59735	12654	50	74	63	J8616	54	73	65

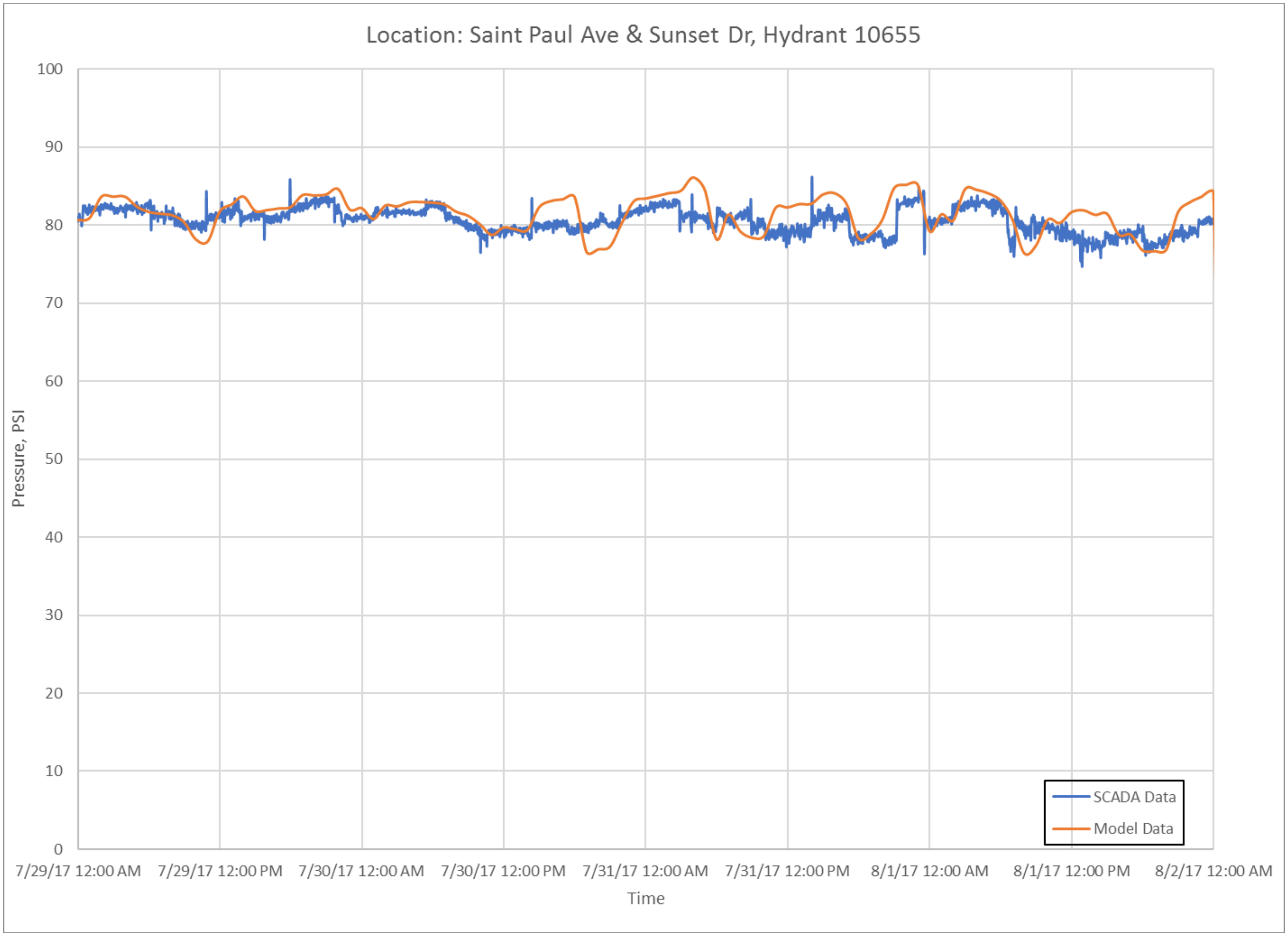


Figure 4-5 Calibration Results at Saint Paul Avenue and Sunset Drive

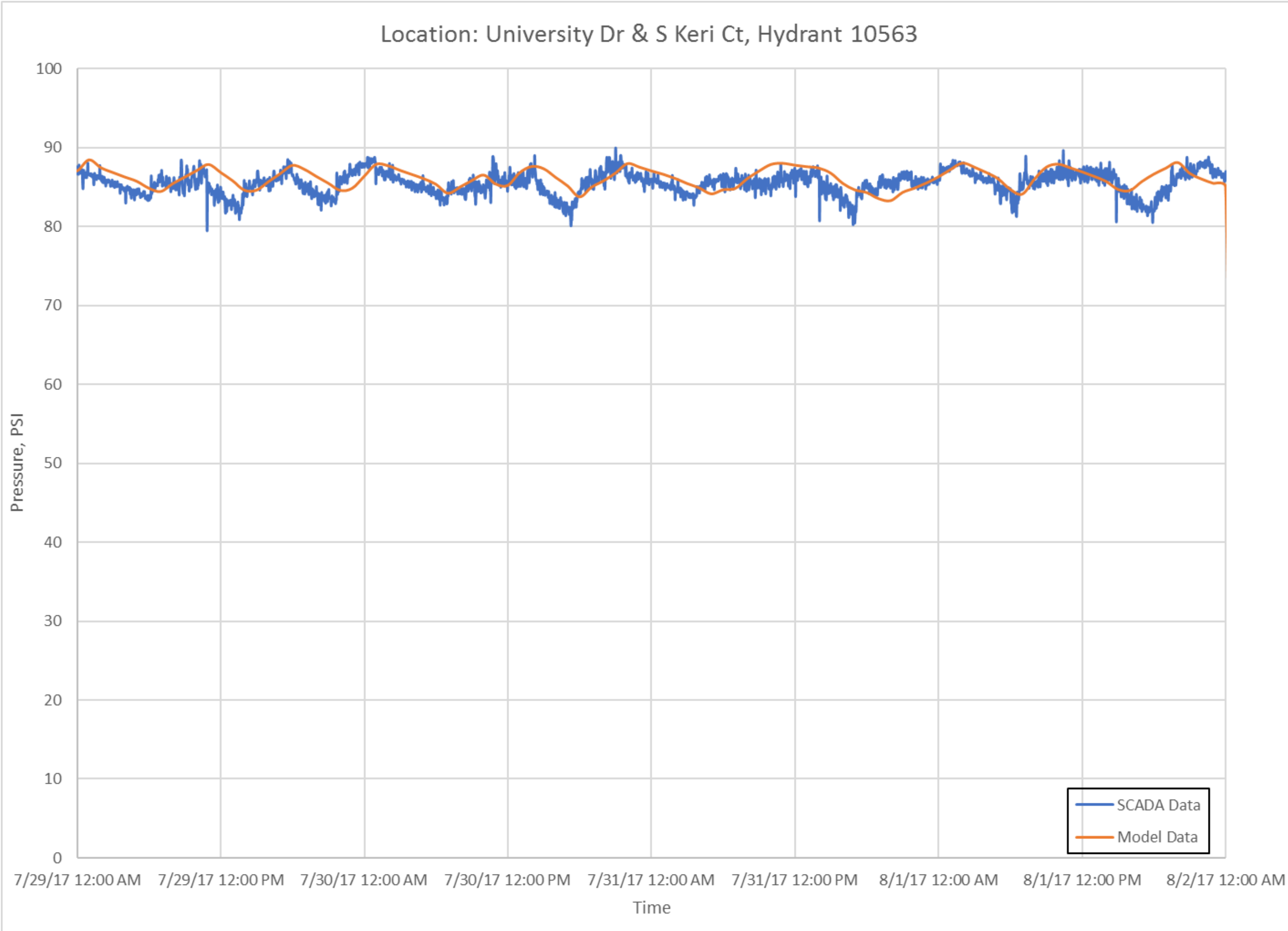


Figure 4-6 Calibration Results at University Drive and South Keri Court

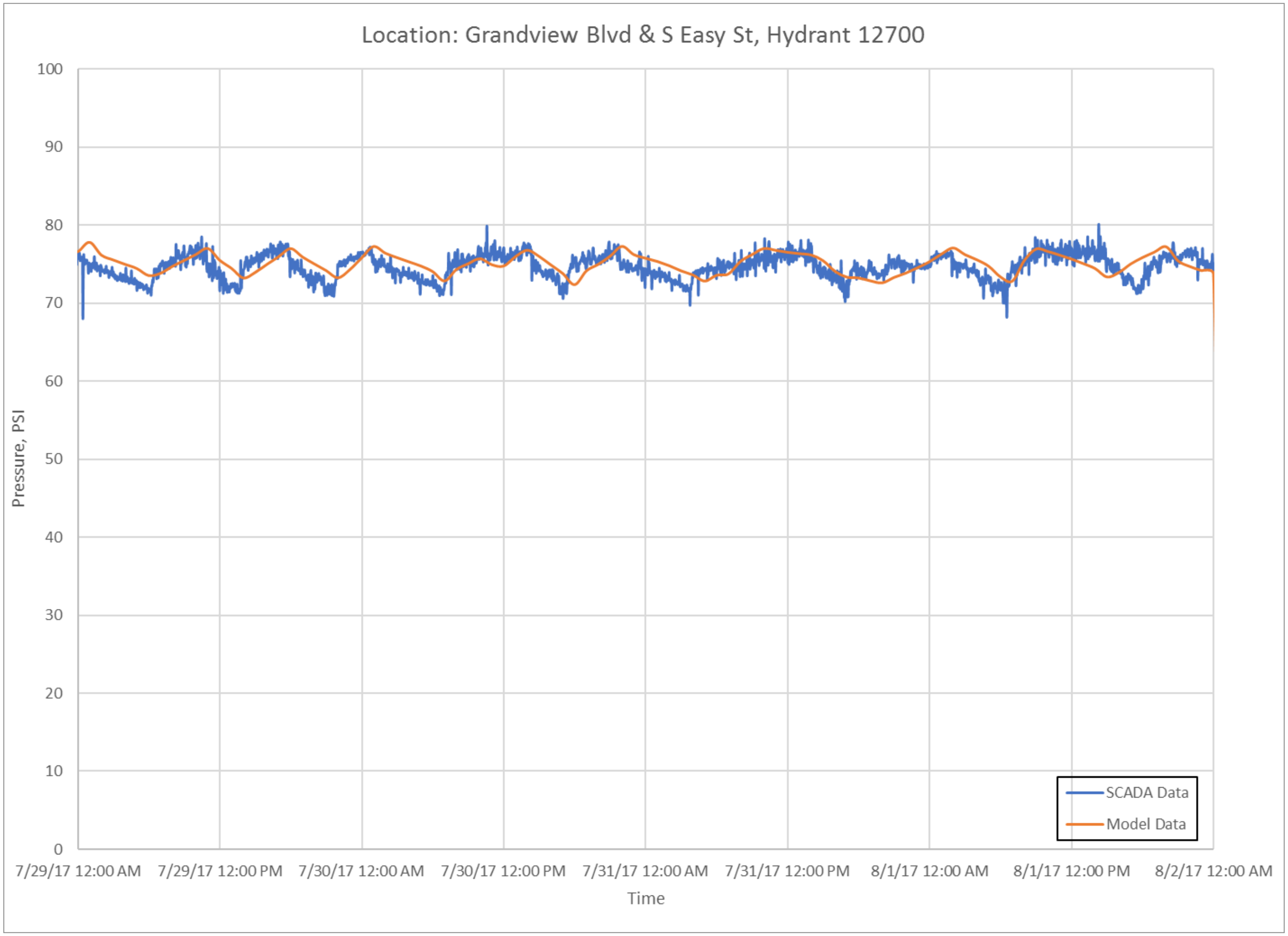


Figure 4-7 Calibration Results at Grandview Boulevard and South Easy Street

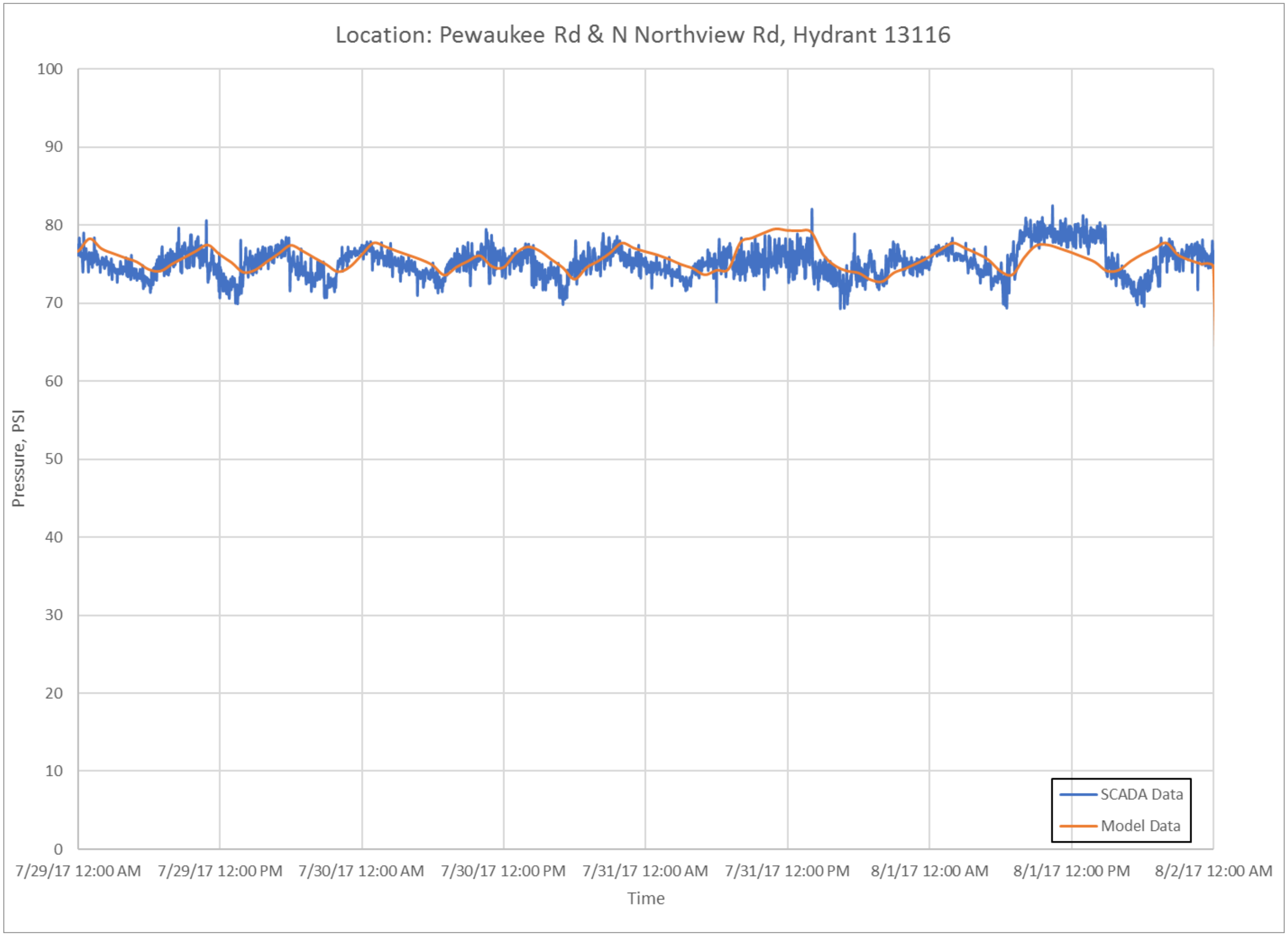


Figure 4-8 Calibration Results at Pewaukee Road and North Northview Road

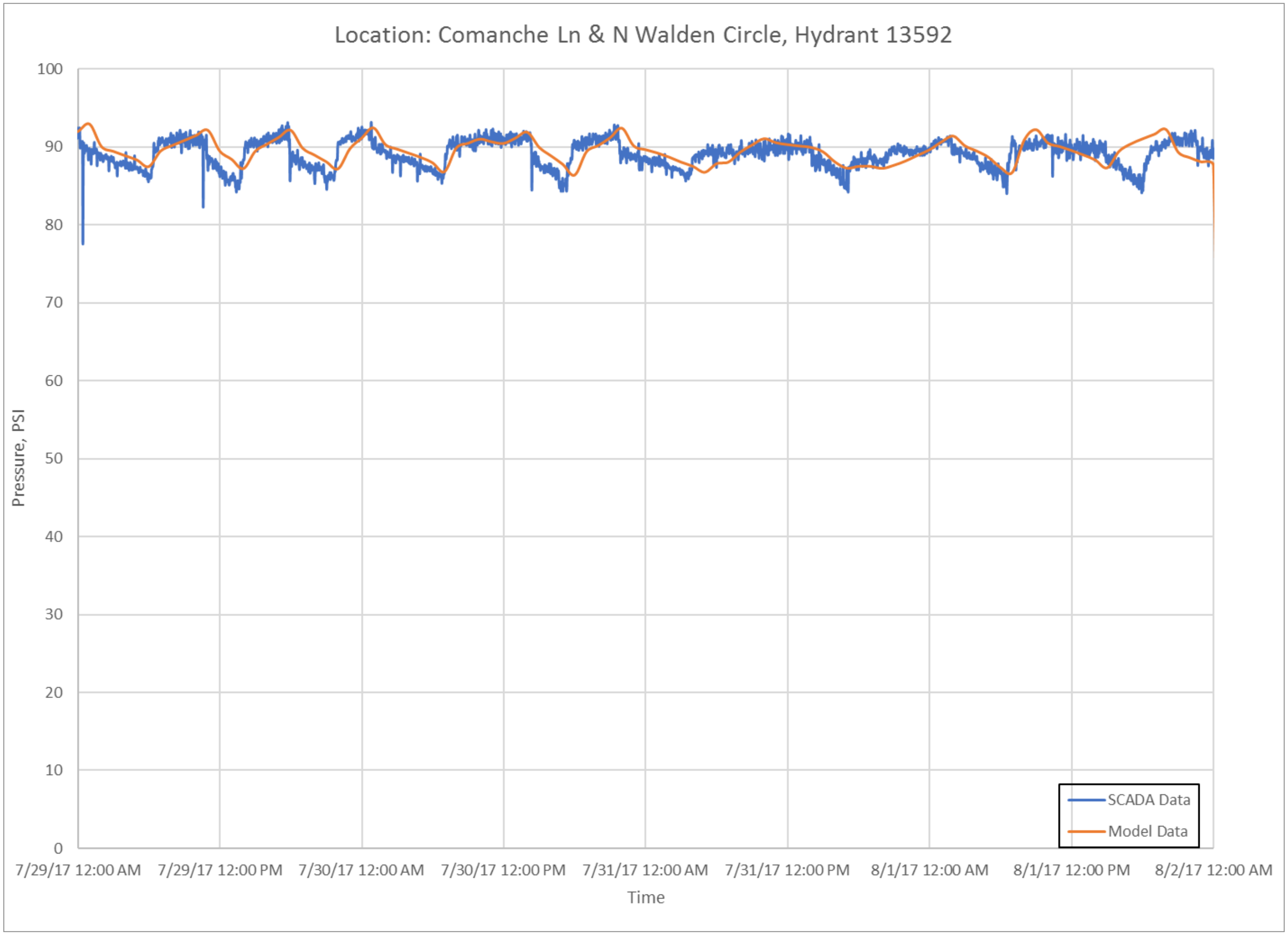


Figure 4-9 Calibration Results at Comanche Lane and North Walden Circle

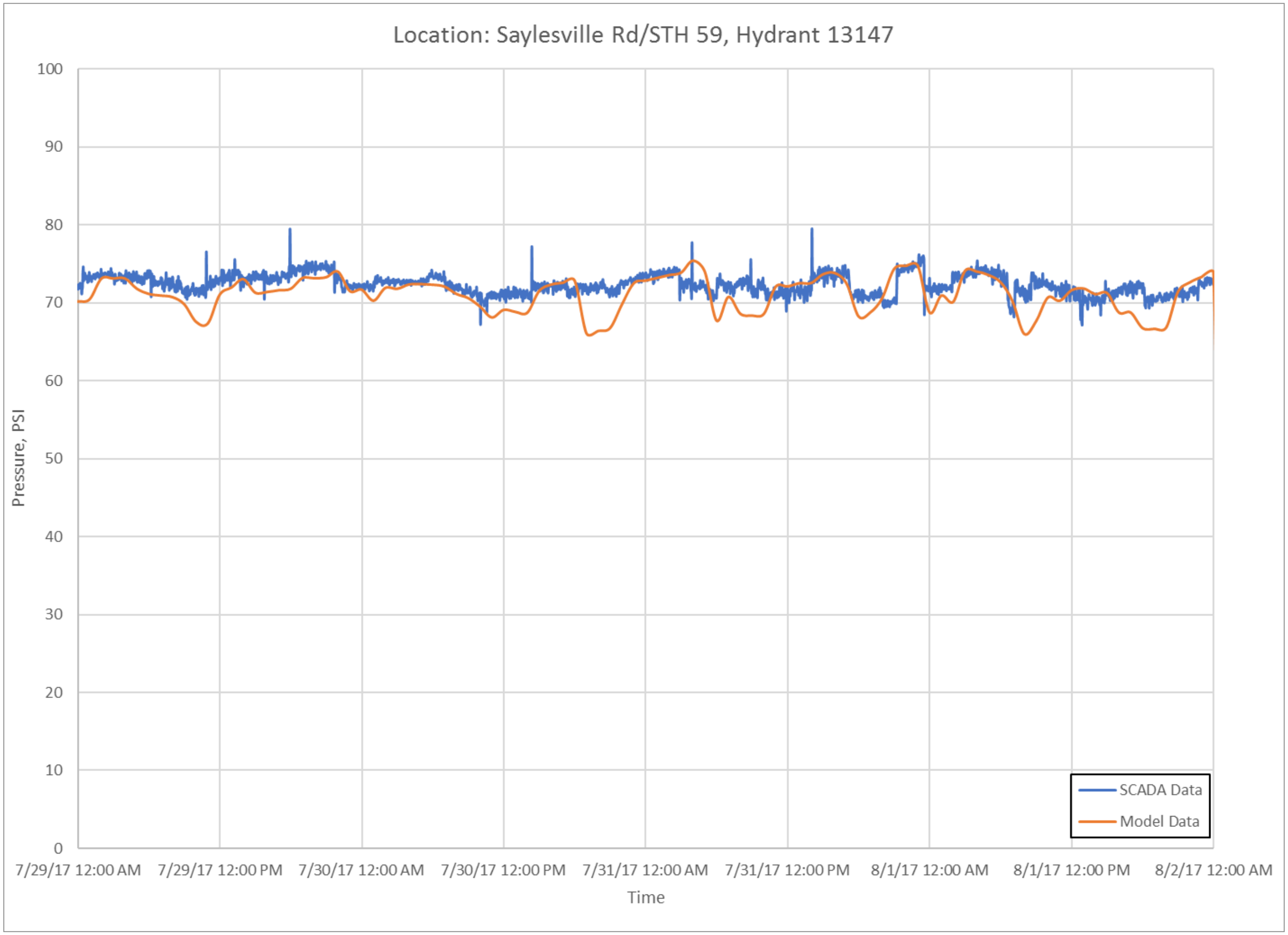


Figure 4-10 Calibration Results at Saylesville Road/State Highway 59

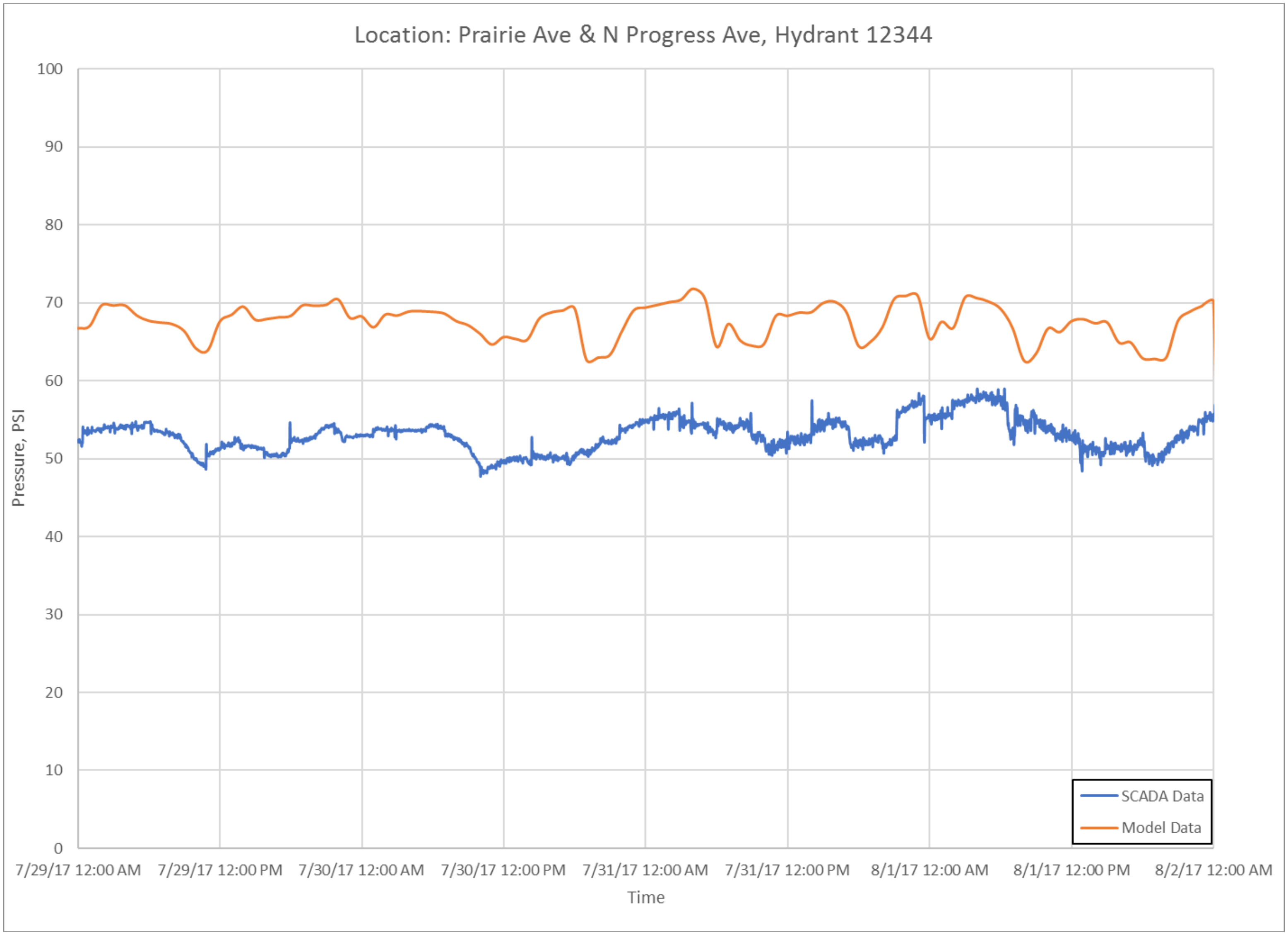


Figure 4-11 Calibration Results at Prairie Avenue and North Progress Avenue

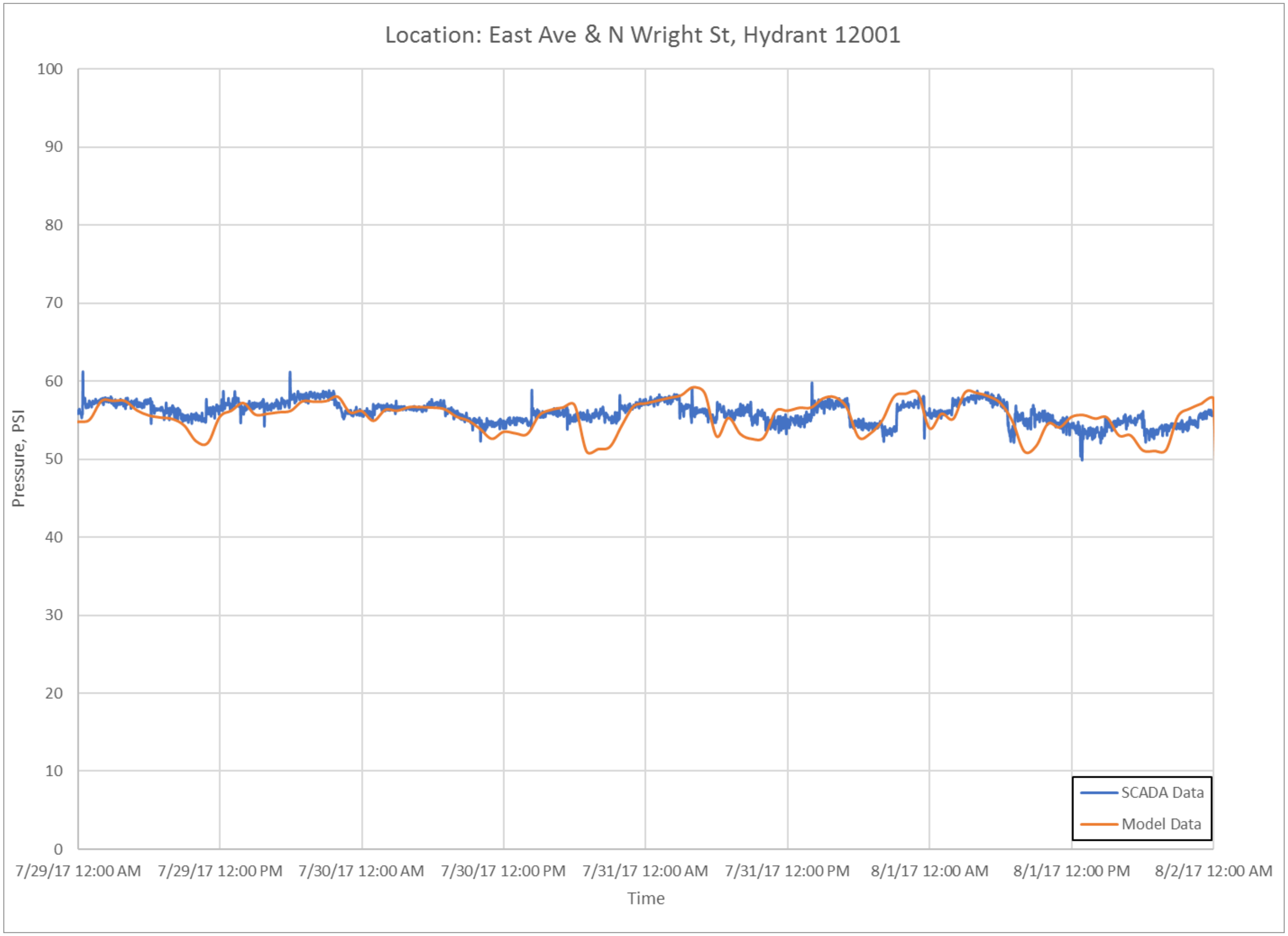


Figure 4-12 Calibration Results at East Avenue and North Wright Street

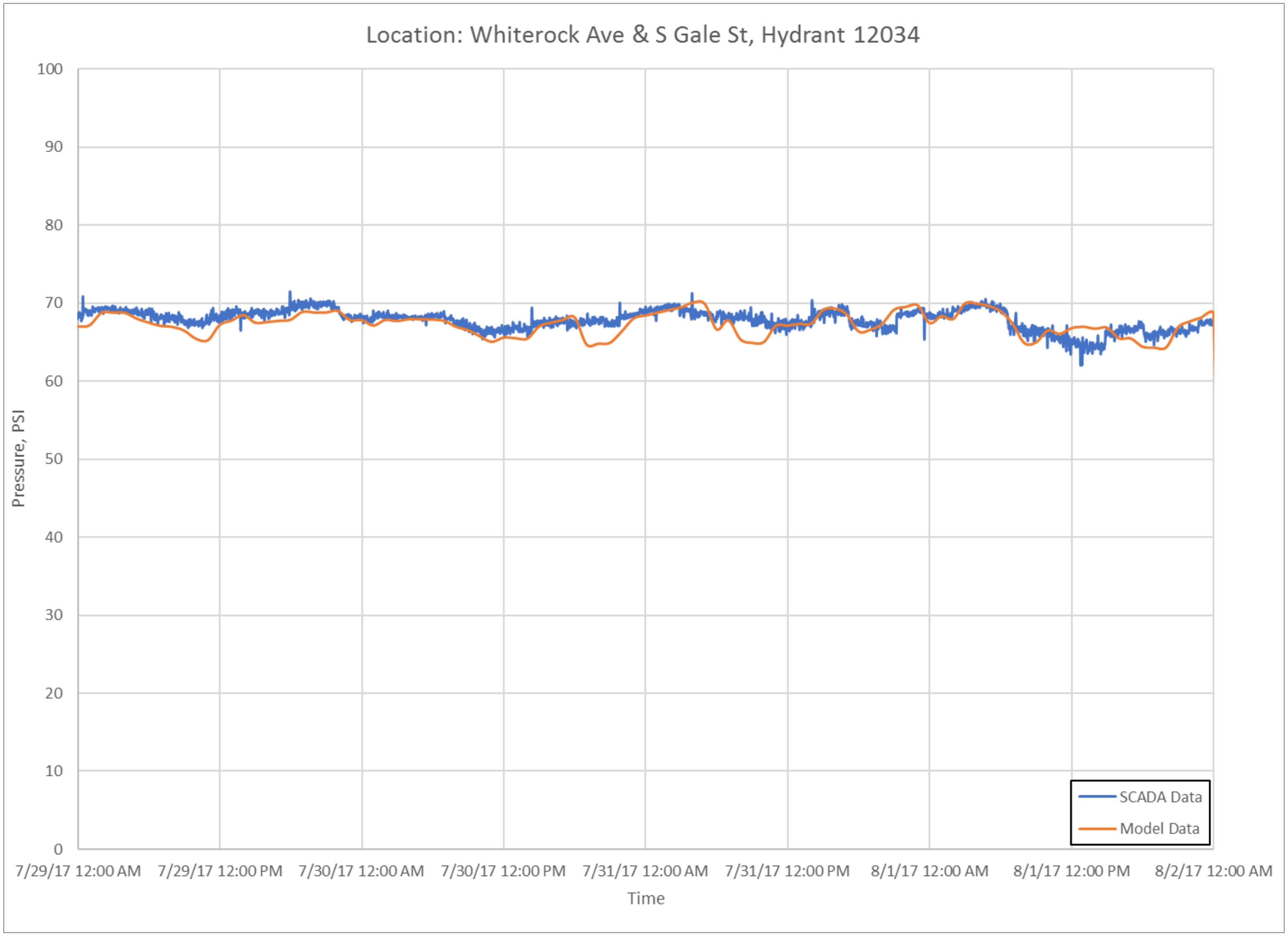


Figure 4-13 Calibration Results at Whiterock Avenue and South Gale Street

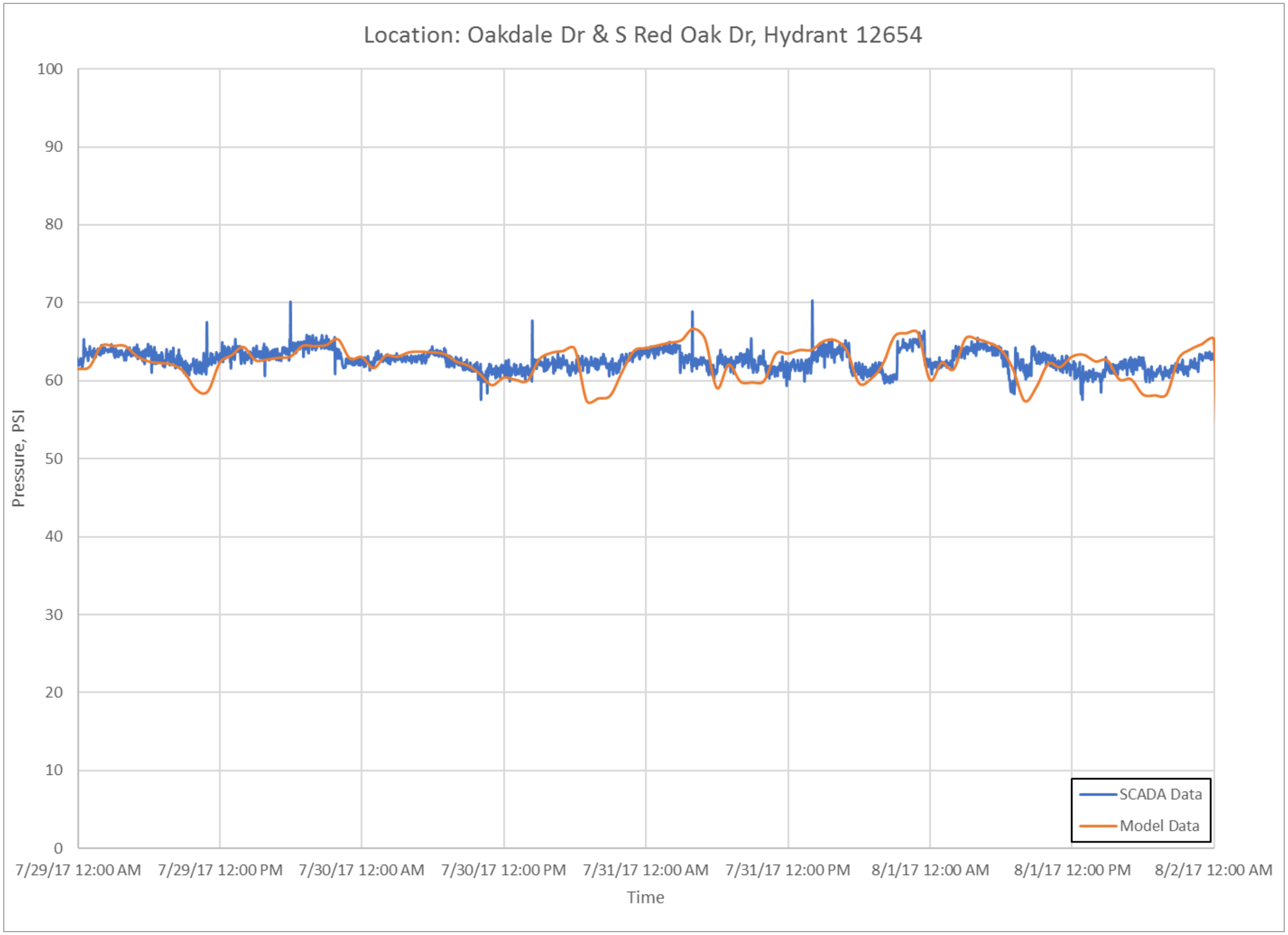


Figure 4-14 Calibration Results at Oakdale Drive and South Red Oak Drive

In addition to the pressure monitor evaluation and comparison, a comparison of the model predicted and SCADA reported tank level variation was performed. The results of those comparisons can be seen in Figures 4-15 through 4-20 below. Davidson Tower is not included since it was offline during the monitoring period. The tank level variation comparison showed that the controls for pumps and operation of the tanks between the expected minimum and maximum levels was consistent between the model predicted operation and the SCADA reported operation. The Hunter Tower comparison shown in Figure 4-19 showed higher variability toward the end of the 5-day EPS analysis where the modeled tank response is drawing down faster than reported in the field. This is most likely due to a larger diurnal demand being applied in the model for the later days of calibration. Even with this slight drift of performance for the Hunter Tower, the model showed good agreement with the SCADA reported operation.

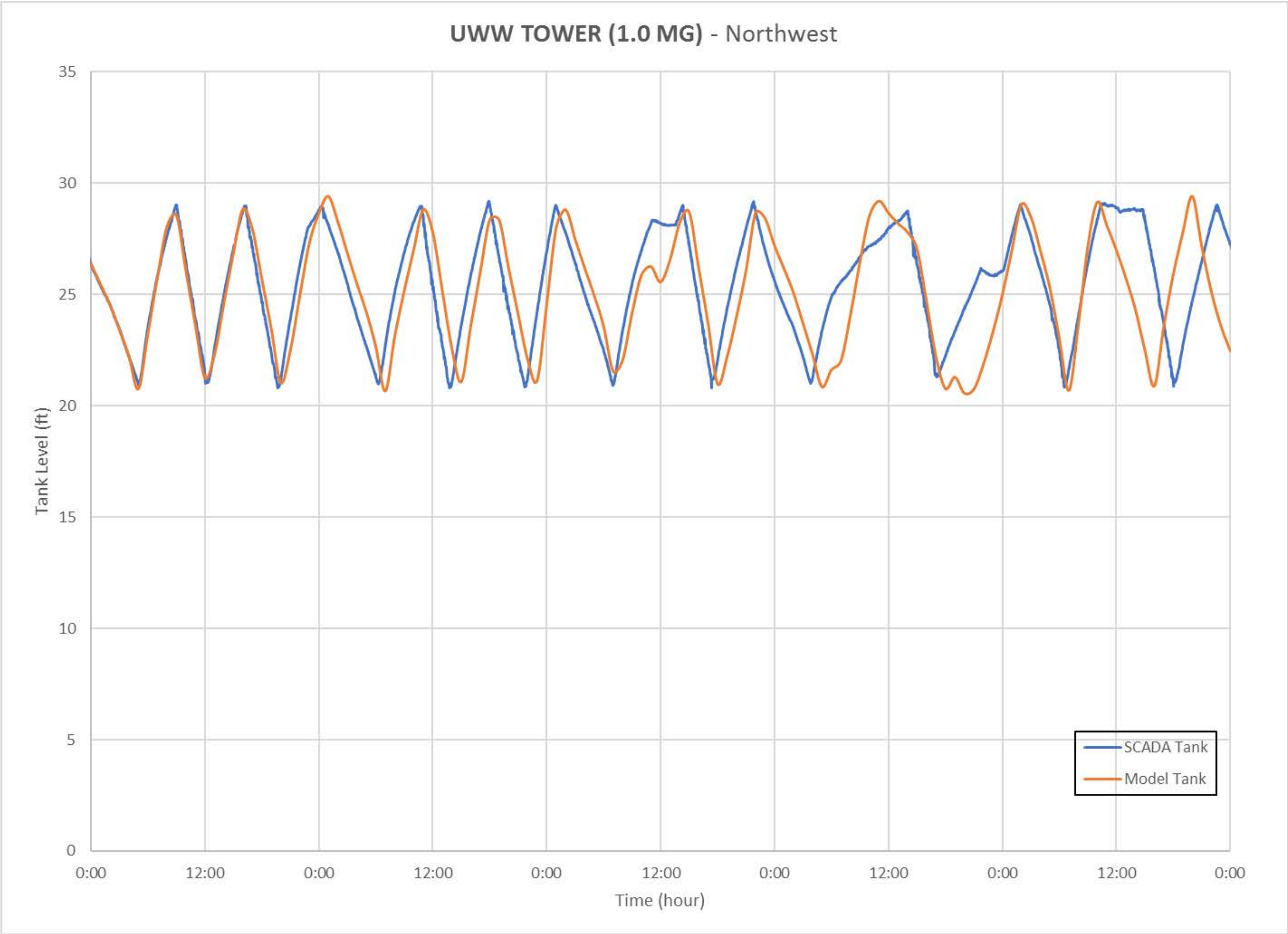


Figure 4-15 SCADA and Model Comparison During EPS Period for UWW Tower

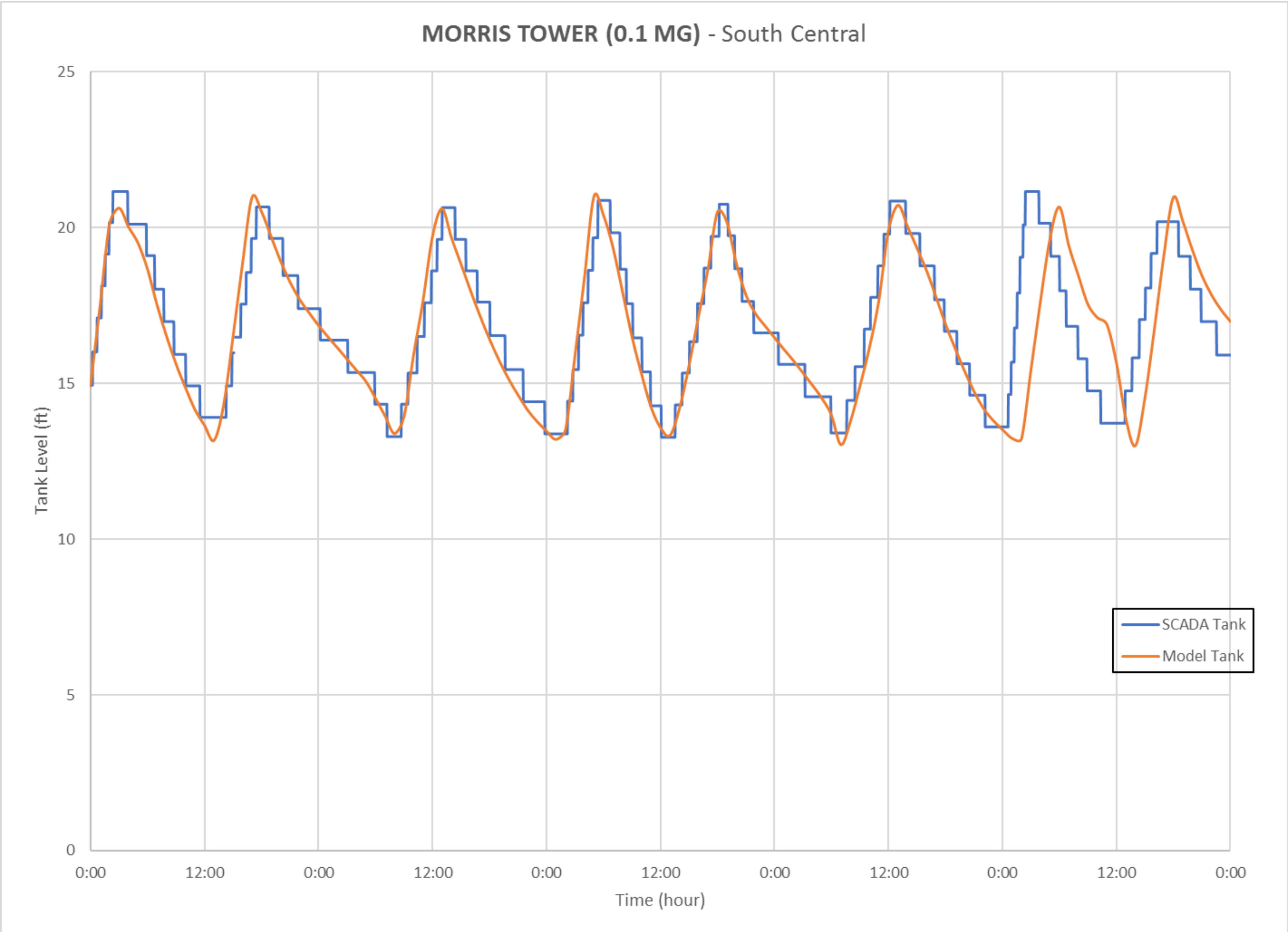


Figure 4-16 SCADA and Model Comparison During EPS Period for Morris Tower

Figure 4-17 SCADA and Model Comparison During EPS Period for Meadowbrook Tower

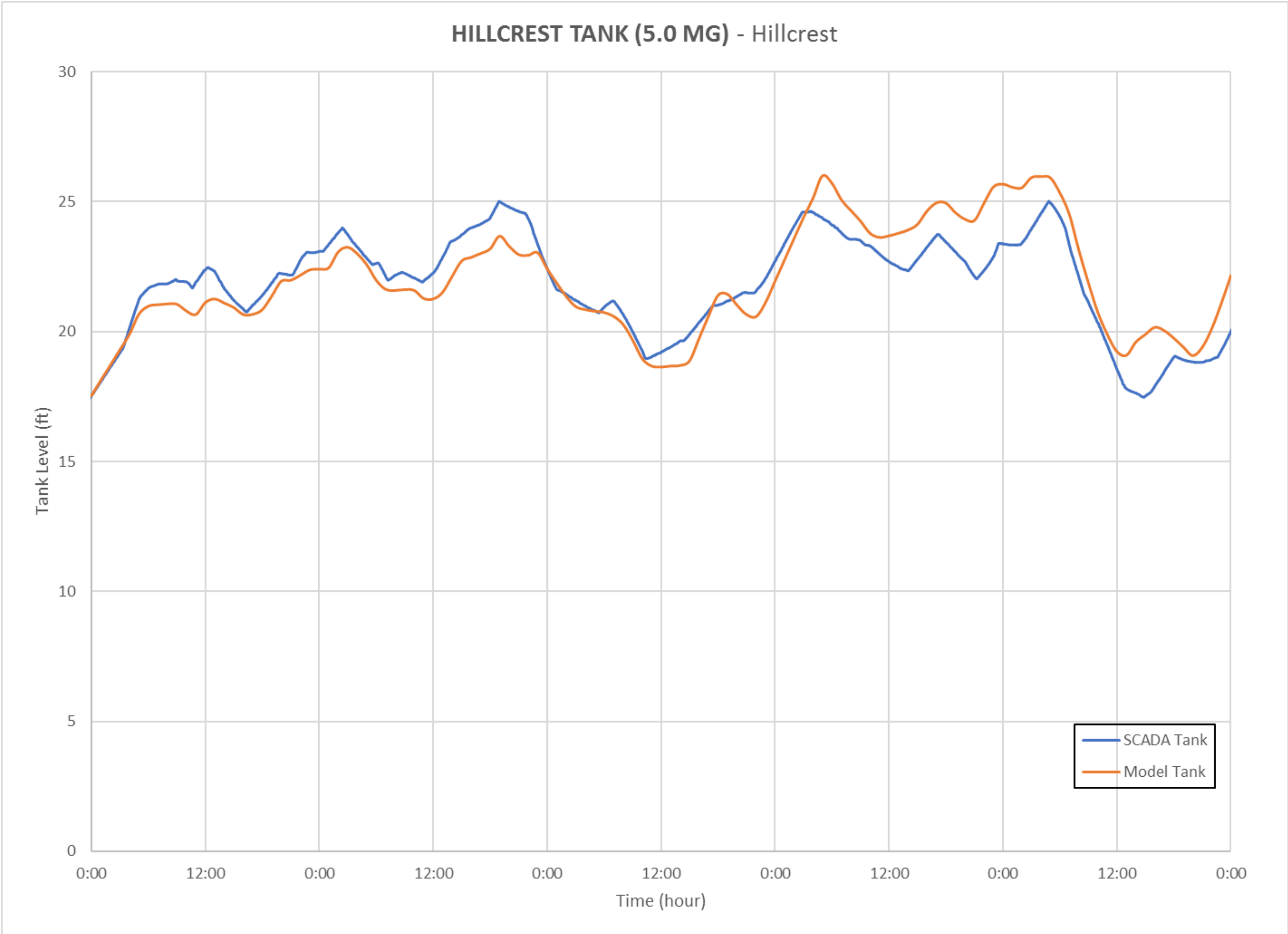


Figure 4-18 SCADA and Model Comparison During EPS Period for Hillcrest Tank

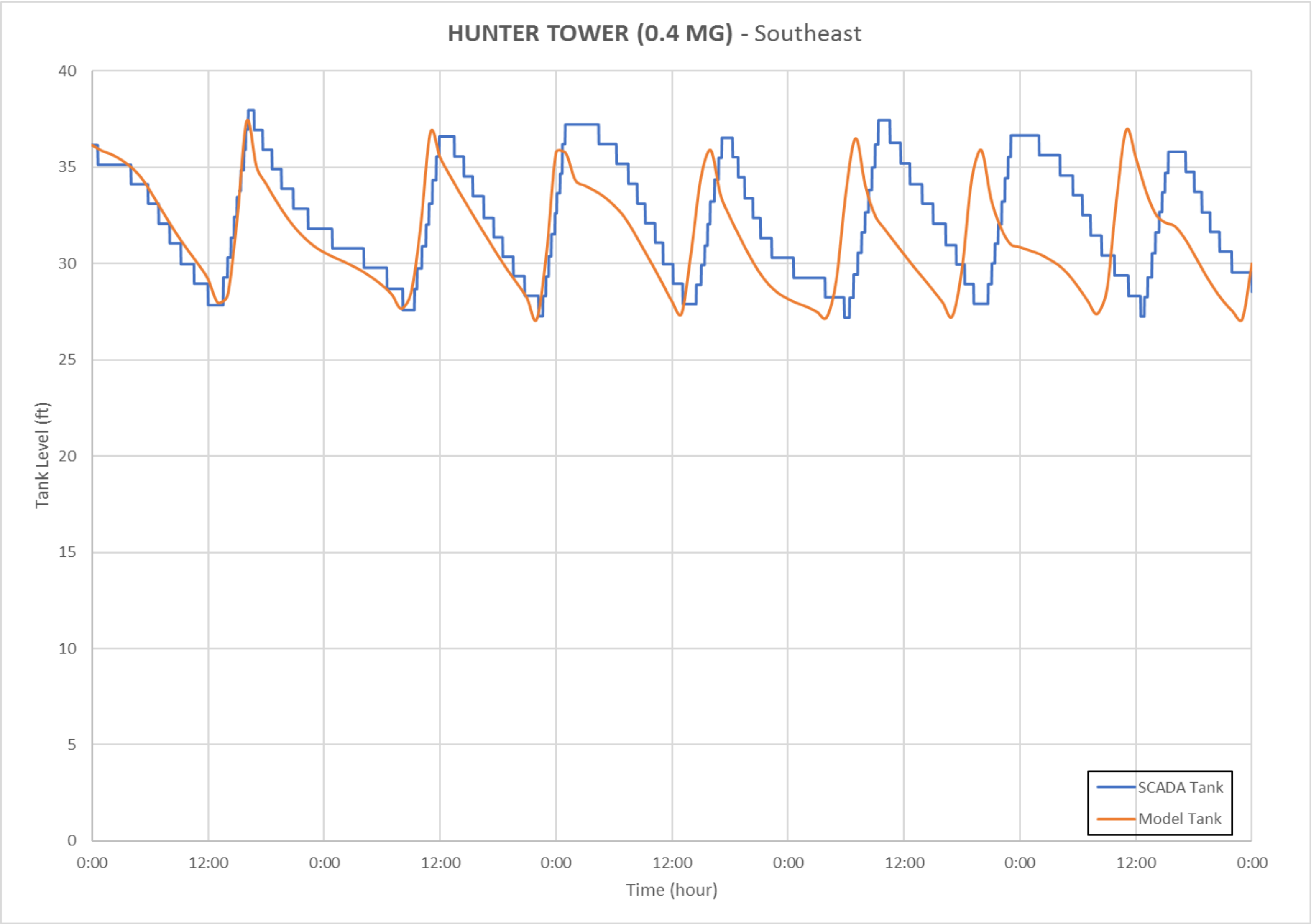


Figure 4-19 SCADA and Model Comparison During EPS Period for Hunter Tower

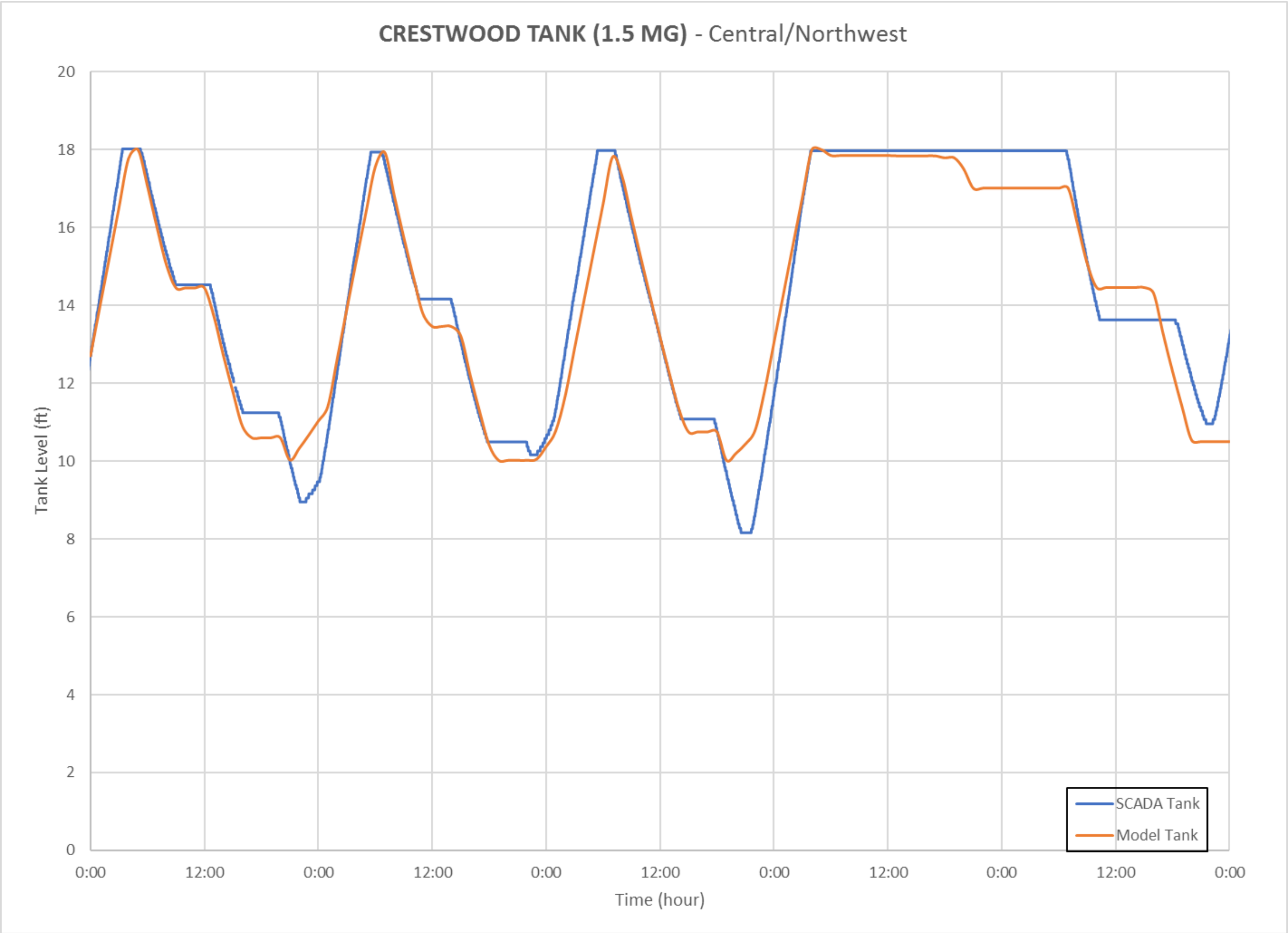
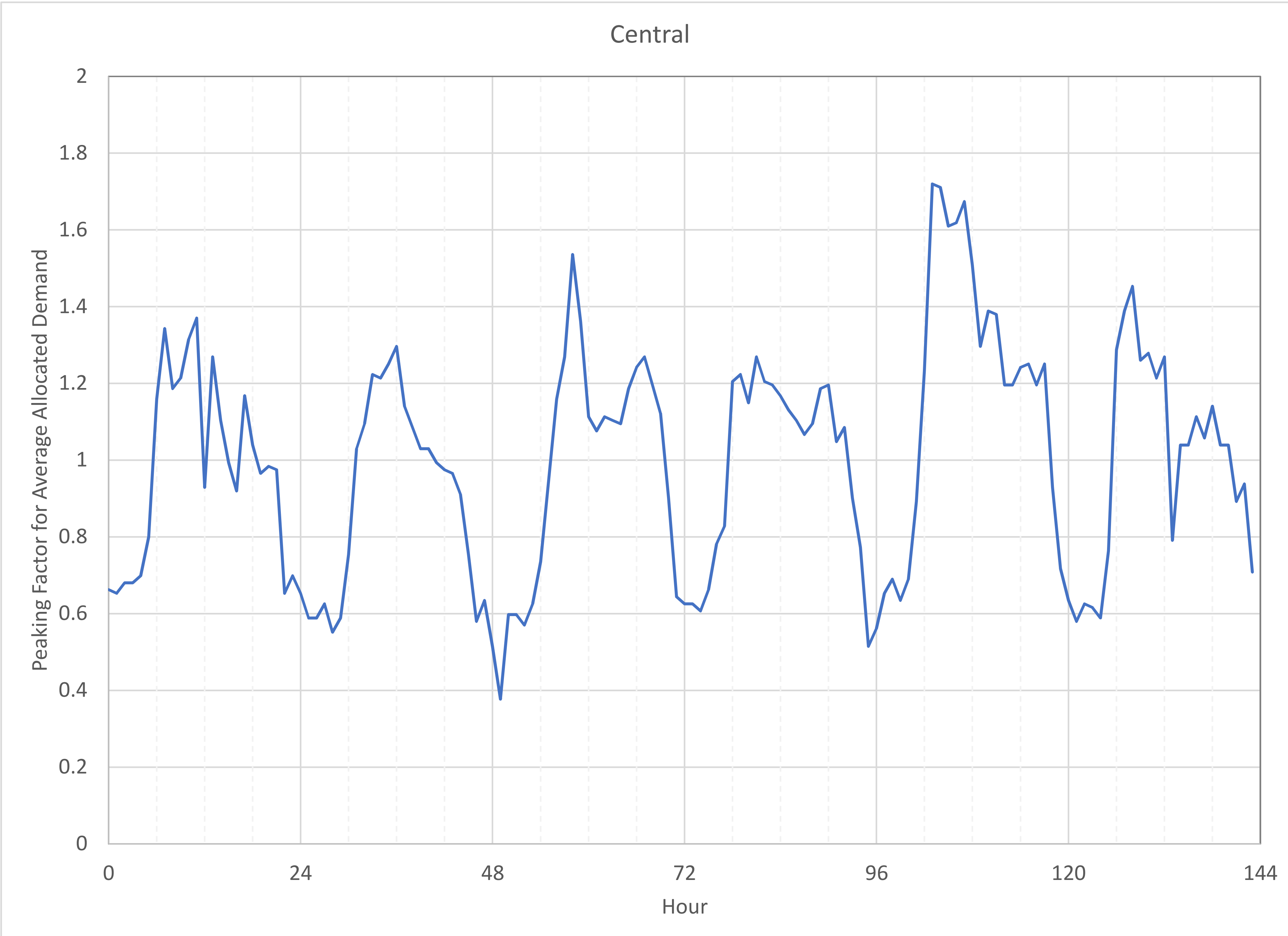


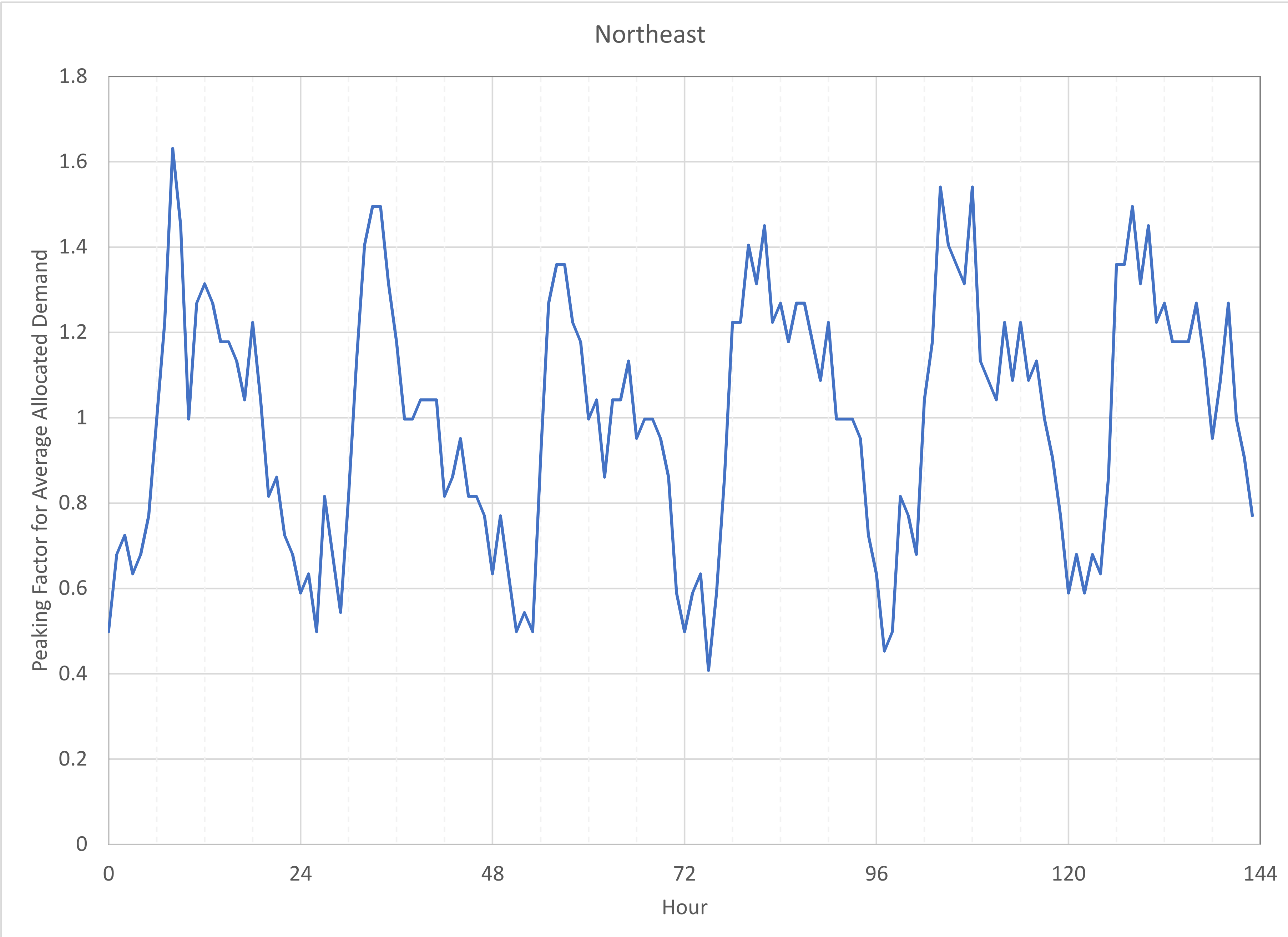
Figure 4-20 SCADA and Model Comparison During EPS Period for Crestwood Tank

SECTION 5 Summary

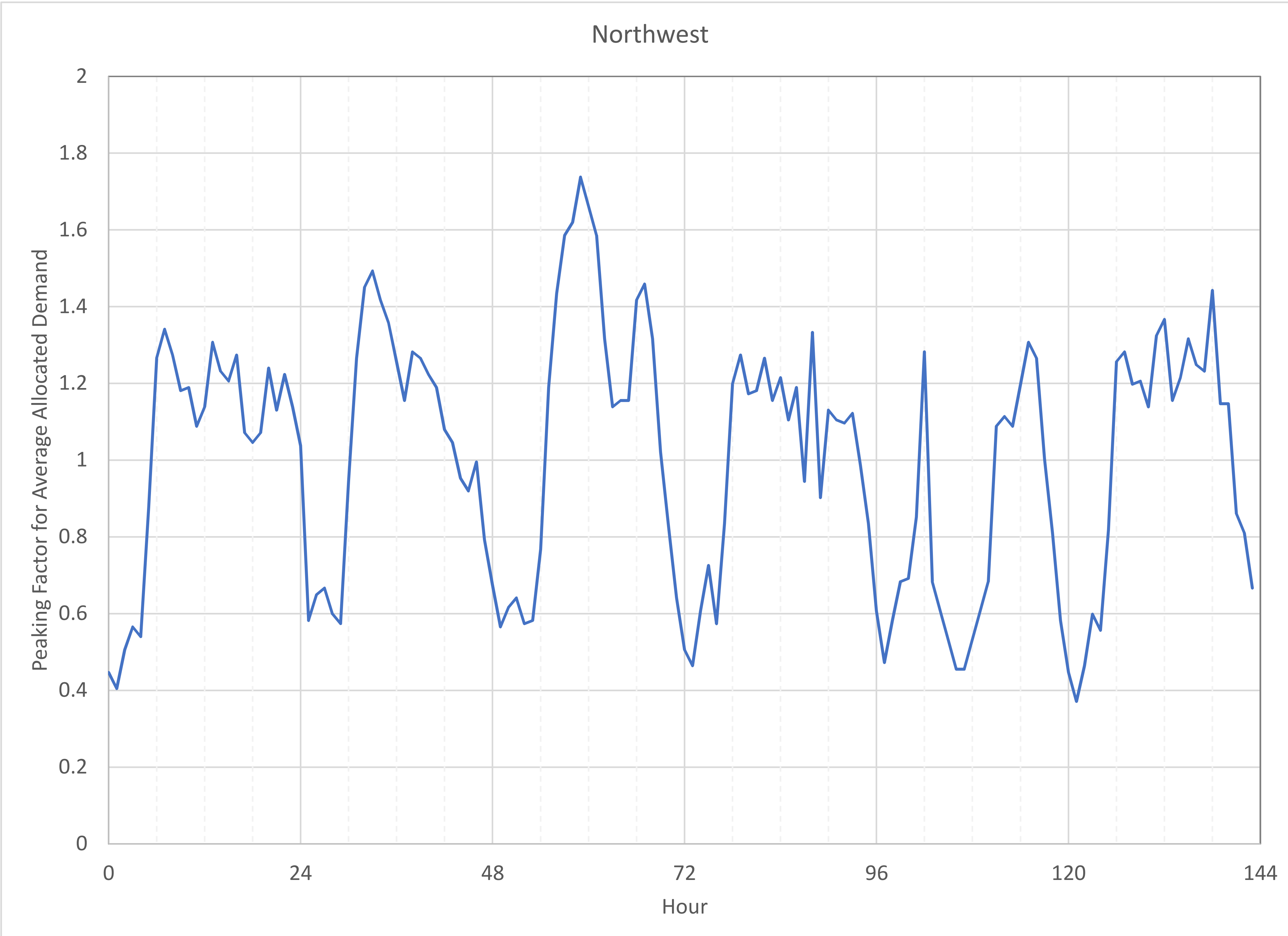
The WWU computerized hydraulic model of the water distribution system was updated with current water distribution network configuration and operational information and calibrated to SCADA and field hydrant test data. The calibration results were within expected ranges, and the calibration of the model is considered successful. The resulting updated and calibrated hydraulic model of the distribution system can be used for many purposes, including system operational optimization and alternatives analysis for future capital improvement projects. Continual updating and model maintenance is necessary in the future to ensure the model remains relevant and can be used for future analyses.

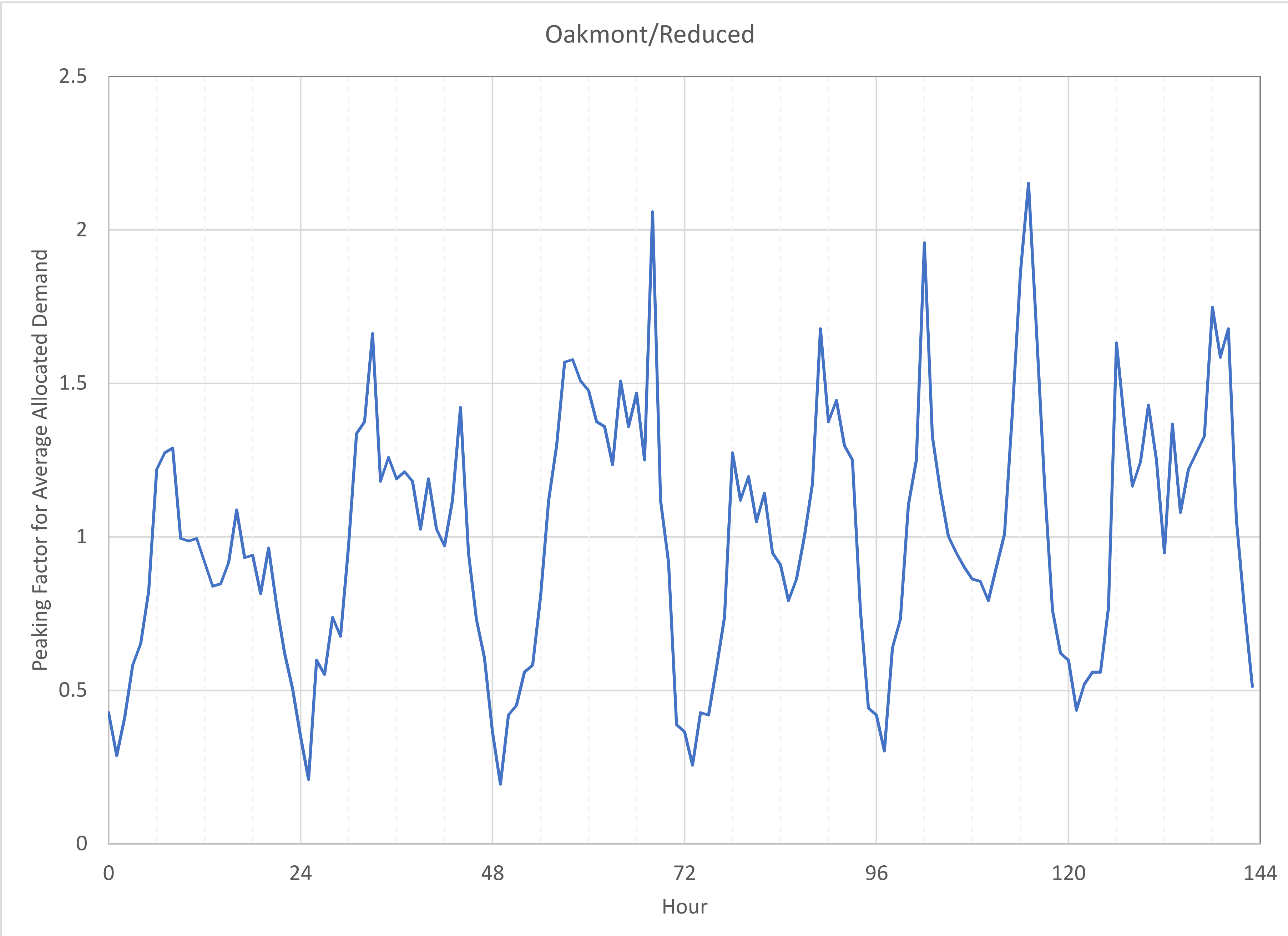
Appendix A - Zone Diurnal Curves

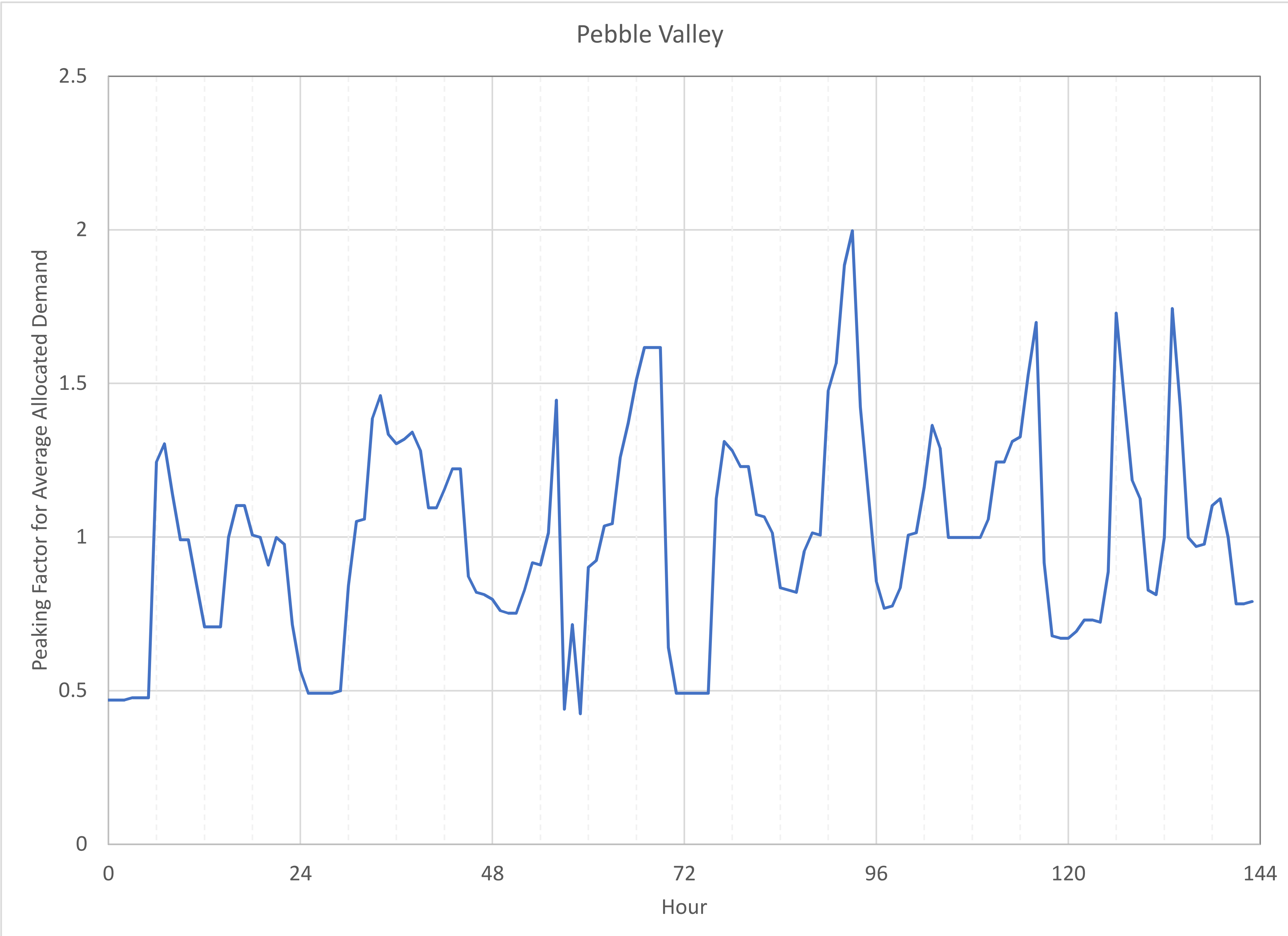

Central
Peaking Factor for Average Allocated Demand
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
0
24
48
72
96
120
144
Hour

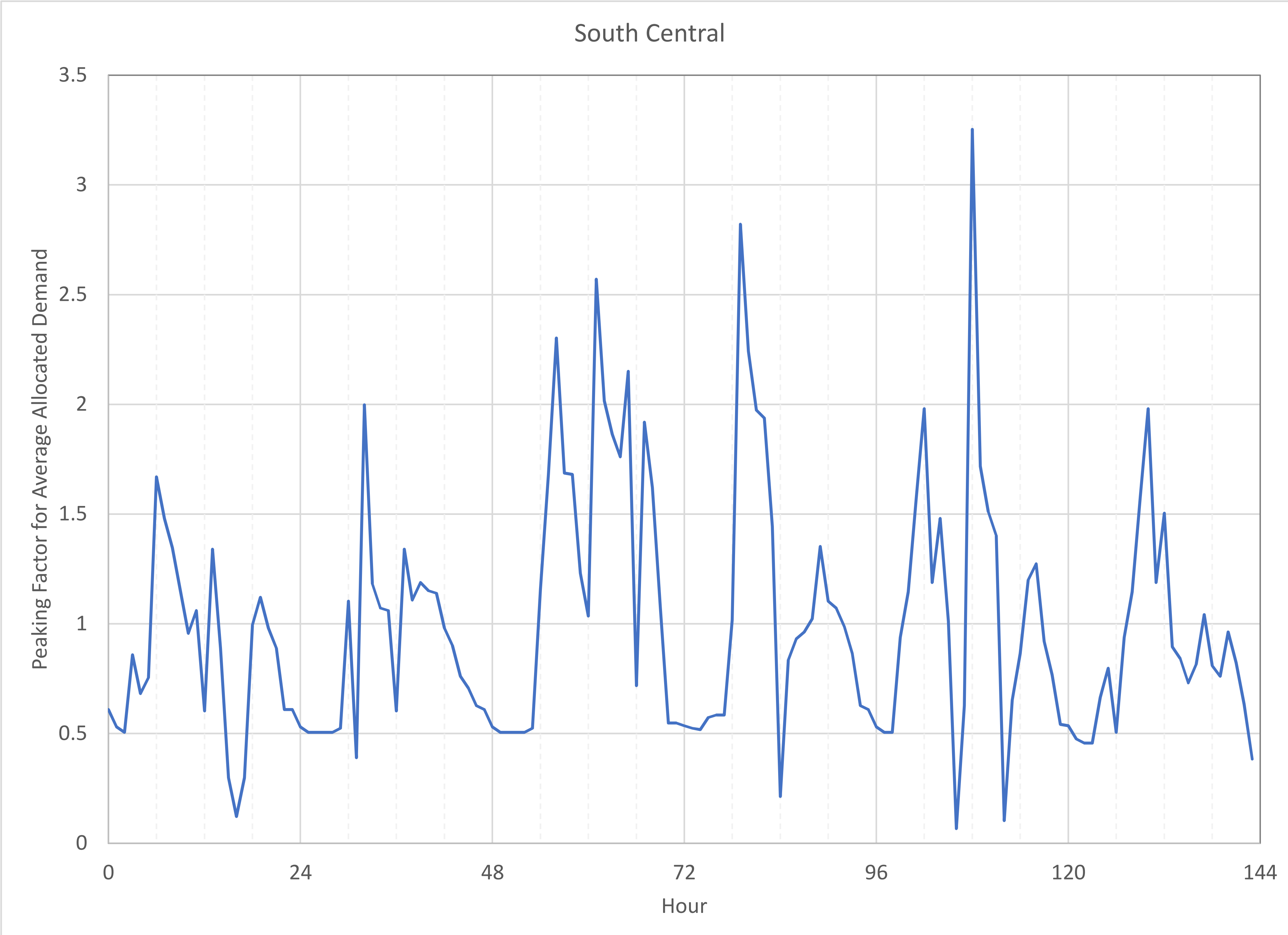


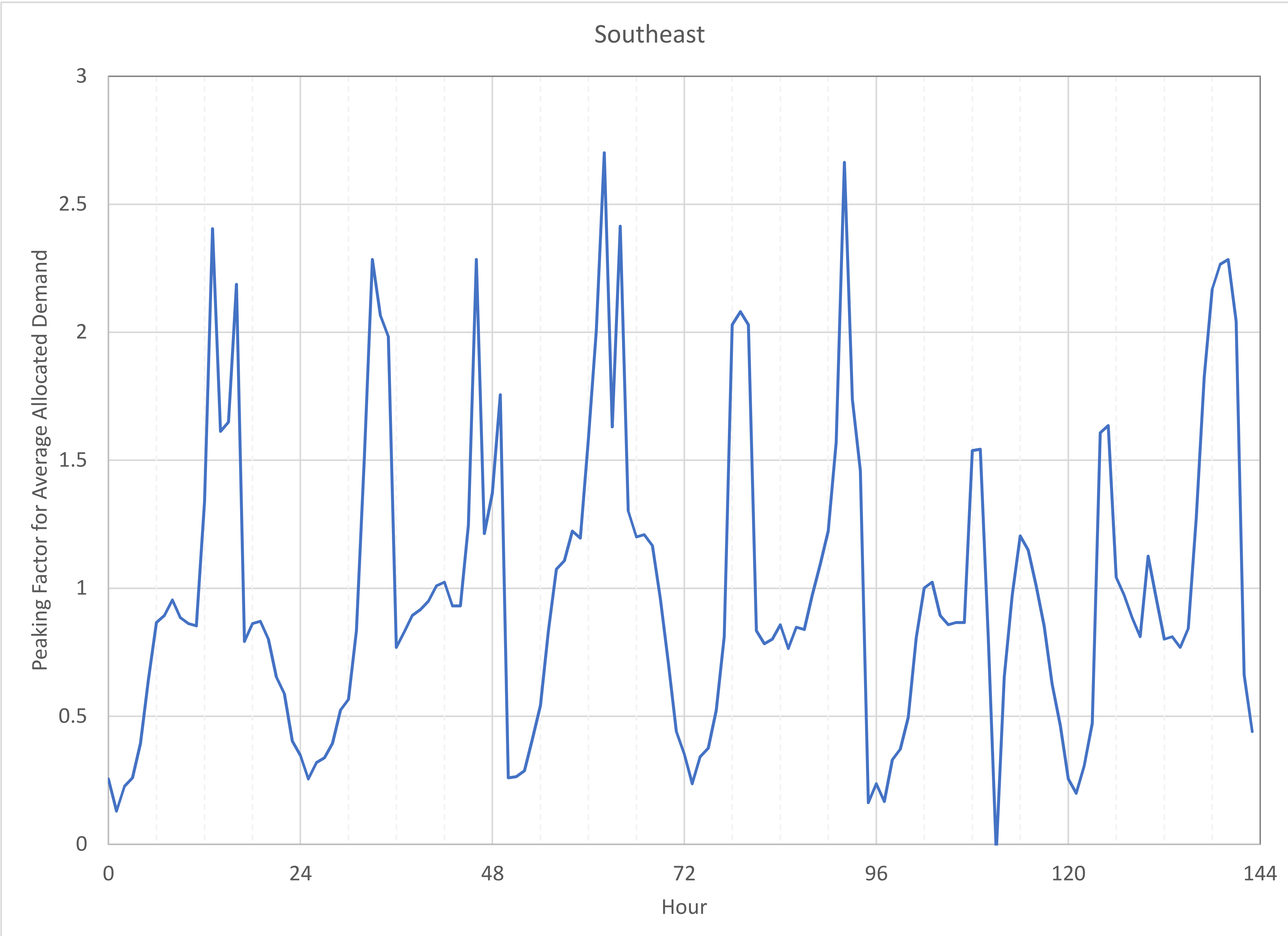
Northeast
Peaking Factor for Average Allocated Demand
Hour
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
0
24
48
72
96
120
144


Northwest
Peaking Factor for Average Allocated Demand
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
24
48
72
96
120
144
Hour


Oakmont/Reduced
Peaking Factor for Average Allocated Demand
Hour
0
0.5
1
1.5
2
2.5
0
24
48
72
96
120
144


Pebble Valley
Peaking Factor for Average Allocated Demand
2.5
2
1.5
1
0.5
0
0
24
48
72
96
120
144
Hour


South Central
Peaking Factor for Average Allocated Demand
3.5
3
2.5
2
1.5
1
0.5
0
0
24
48
72
96
120
144
Hour



Southeast
Peaking Factor for Average Allocated Demand
3
2.5
2
1.5
1
0.5
0
0
24
48
72
96
120
144
Hour

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